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JANUARY 13, 1927

Engineering News-Record

This issue is A REVIEW OF ENGINEERING *at the beginning of 1927*

IT CONTAINS

A Survey of the Developments in the Field of Civil Engineering and Construction
By the Editors

A Pictorial Résumé of the Important Engineering Construction During the Past Year

A Summary Giving in Short Paragraphs the Current Status of the Major Engineering Projects

Four Articles Bringing Up To Date the Progress in Important Allied Engineering Fields:

CEMENT MANUFACTURE
By F. W. Kelley
President, North American Cement Corp.

RAILWAY MOTIVE POWER
By E. C. Schmidt
Professor of Railway Engineering, University of Illinois

BUS TRANSPORTATION
By Carl W. Stocks
Editor, Bus Transportation

STEAM POWER PLANTS
By C. H. Berry
Associate Editor, Power

AND

Engineering News-Record Construction Cost and Volume Statistics for 1926

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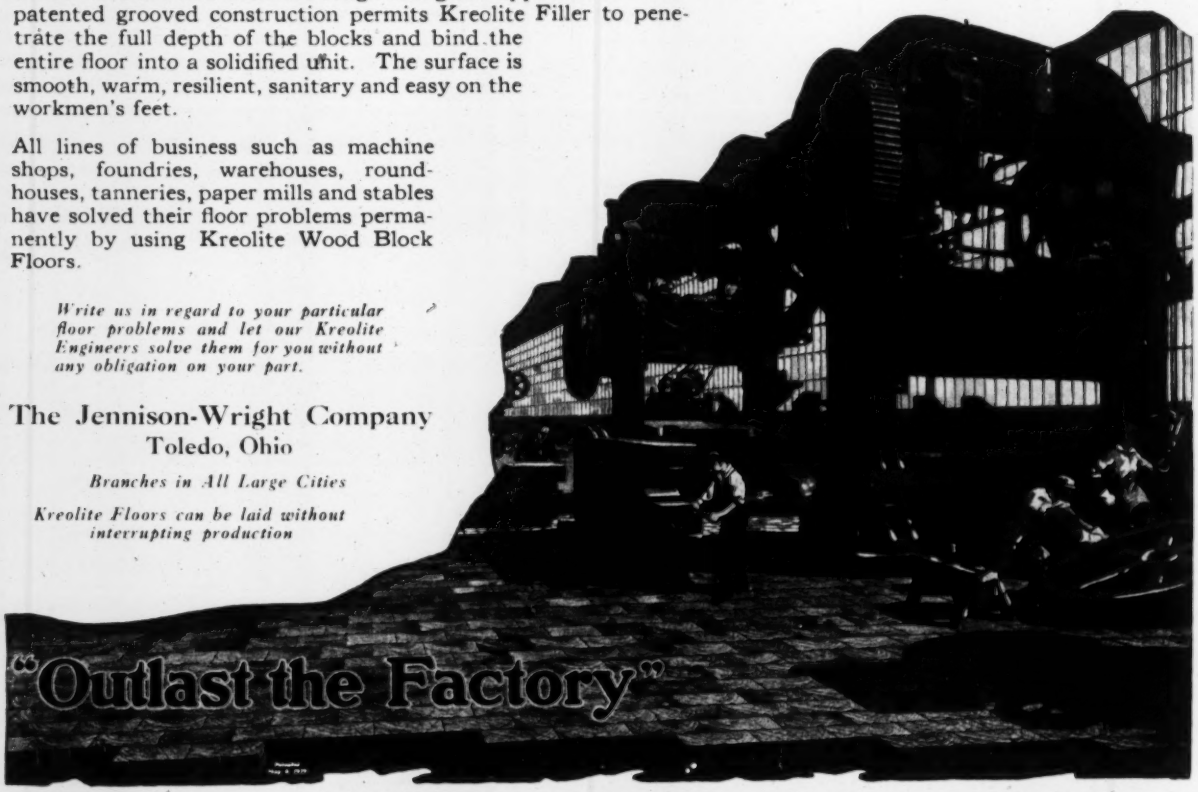

WOOD BLOCK FLOORS

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

McGraw-Hill Publishing Co., Inc.
JAMES H. McGRAW, *President*
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FRANK C. WIGHT
Editor

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Civil Engineering and Construction at the Beginning of 1927

AN EDITORIAL REVIEW

AT the beginning of every year *Engineering News-Record* presents a survey of the accomplishments of the year just gone in the field of engineering and construction, with a prognostication, in so far as it is possible, of the year to come. This issue is devoted to that survey of the immediate past and future. It comprises comment on the status of engineering by the editorial staff, which is the content of the pages next following; a series of articles by experts on four separate phases of engineering with which the civil engineer and constructor have little specifically to do but the ramifications of which may well affect their work; a portfolio of photographs of notable engineering structures of current importance; a brief review of the status of those major engineering projects now under way or imminent; and finally the annual collation that *Engineering News-Record* makes of the statistics of construction, its costs and its volume.

The State of Business

EXAMINATION of material performances of the year just past and contemplation of the year now beginning lead but to one thought: Will the prosperous progress of American business and industry continue unabated or is there in sight the depression which history has taught us is inevitable? To a hitherto unheard-of degree the business world this year has been treated to a succession of prognostications. Statistical science has taken business by storm and every bank and every industry, as well as every public official, have published reviews of the material conditions in this country with predictions of the course of business for twelve months to come. It is not the purpose of *Engineering News-Record* to review this flood of prophecy nor to adduce the numerous bases for the almost unanimous voicing of optimism. It is sufficient to say that in the year just past once more the indices of prosperity in this country pictured a record, that production flourished, but at a low enough cost to permit a price within the capacity of the enlarged purchasing power of a highly paid and fully employed people and that hand-to-mouth buying still justified itself as a sane balance wheel to reckless production. Except for the rational human expectation that all good things must some time end, there is no real indication that the era of prosperity should not continue for at least another year, provided always that too many individuals do not run wild in the thought that the millenium has arrived and that nothing can stop the continually mounting production and consumption of all kinds of goods. An overweening confidence in the eternity of good times may produce a carelessness of expenditure, a riot of overproduction, an unreasonable extension of credit, and set up an unbalanced physical and material condition which would be the beginning of the drop in the current prosperity.

A Look Ahead

THERE are few signs of such a prospect though it must be admitted that many business men are seeking hard to justify their expectations of inevitable depression. With few exceptions, our industries are sound. The textiles, suffering from lack of leadership, from too intense individuality and from natural reductions in consumption, are far from healthy. Speculative building has run rampant with obvious indications in most of our large cities that overbuilding is upon us, but much of the professional statistician's talk about overexpansion of building is based on this less than 20 per cent of the total construction of the country. Building labor, the most highly paid labor in the world, seems to be not quite satisfied with the commanding position it has attained and, like Oliver Twist, asks for more, with consequent ominous possibilities in the way of a buyers' strike. Certain of our heavy material producers are suffering to a degree from European competition in our coastal areas. The farmer continues to be the abused step-child of the nation. All these are the clouds in the domestic offing, but none of them show signs as yet of

becoming wracking storms. As one reads the newspapers, one comes to believe that prohibition is the only national issue. For a time men and policies must bend to the sumptuary law. It is extremely unlikely that anything of a legislative or executive nature will take place during 1927 that will have any effect upon the economic status of the country, nor that the international situation, unfavorable as it may appear in many aspects, will react adversely to our material progress.

Remembering then we are at a peak of well-being and that it is not possible continually to increase our collective individual incomes, either real or psychic, the year ahead for engineers and constructors can be viewed without alarm. How it has progressed in engineering and construction, and what that progress promises for the future is the text of the succeeding columns.

Construction Past and Future

EACH year since 1922 it has been our pleasure—not unmixed with a little wonder—to report a volume of engineering construction of greater value than that for the year preceding. This year's history is the same—the 1925 record was smashed.

This year's total is $2,851,786,000 for contracts reported in the Construction News section of *Engineering News-Record*, compared with $2,559,443,000 for 1925. This covers industrial buildings of $40,000 and more, other buildings of $150,000 and more, and construction other than buildings of $25,000 and more. Thus, the year shows a gain of 11 per cent over 1925. Right here it is worth saying that despite this large increase in demand for materials, the *Engineering News-Record* Construction Cost Index Number rose only 2 per cent from January, 1926, to January, 1927.

This contract figure, large as it is, does not cover all construction. When to it are added the smaller construction jobs and residential buildings the grand total becomes about $7,800,000,000, compared with $7,500,000,000 in 1925 and $6,000,000,000 in 1924.

There is a limit to everything, but from all statistics available the limit in number and value of engineering structures is not yet in sight. In the latter part of 1925 and early in 1926 predictions were freely made that there would be a break in construction in about the middle of the year. There was no break. True, speculative building and small residential building contracts fell off in May and continued down until the bottom was touched in July, since which month the trend has been upward. Despite this slump, however, the tremendous activity in large construction projects pushed the total contract figures well over the 1925 line. The outlook for construction in 1927 is treated in greater detail in the statistical section of this issue. Sufficient here to say in conclusion that prospects for 1927 look good.

Construction Technique

CONSTRUCTION planning has progressed notably as a consciously undertaken engineering design problem. A co-ordinate development is an increased mechanization of construction operations. These facts are evidenced on construction jobs by almost as complete a set of drawings of plant location and structures and schedules of machines and tools as of structure and of construction materials quantities. It, too, is becoming increasingly common to find the small operation as well as the large, well planned and thoroughly mechanized.

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In this forceful trend toward mechanization a concurrent danger which has developed, and is often seen to have caused trouble, is machine multiplication without equipment plan and co-ordination; the constructor has a lot of machines but not a unified construction plant. With increased mechanization, construction superintendence too has become a task only for the most capable men and the men who are willing to call in the specialist as advisor and director.

As exemplifying the conversion to machine construction at every opportunity, the subway building operations in New York can be pointed out. Here, one of the most intricate tasks of timbered excavation of which engineering construction has experience, a task which a decade ago would have been considered generally practicable only by hand, is being performed by power shovels and motor trucks. There is more of this change, be it noted, than substituting machines for men; there had to be a new development of timbering and a new planning of hauling and spoil disposal procedure.

The mechanization is but an element of the construction planning. This coalition is not the creation of twelve months but it has in the last year gained conscious recognition and acceptance beyond anything it had had before. With machinery and the better direction that the full mechanization of operations requires, there has come generally better fabrication. Construction gives a better product generally than it did. This cannot all be credited to the use of machinery; more exacting engineering played a strong hand and there were other influences, but neither can mechanization be denied largely the credit. It demands higher managerial talent and more capable and skilled workmen and a reflection is had in better product.

In the largest operations of the year a consideration far beyond common has been given to personnel and to ways of encouraging a zest for efficiency among workmen. Indeed in none of its special functions does construction engineering show a lag in detail practices or in broad planning compared with engineering design.

Building Progress

FOR some years there has been feverish activity in constructing tall city buildings, for office, apartment and warehouse use. This activity continued well during 1926, showing, however, a slight beginning of slacking off. The buoyant and somewhat bizarre spirit back of some of this activity revealed itself in a number of proposals for buildings of very great height, including one of some 80 stories in Detroit, another of more than 100 stories in New York, and one or two of somewhat less ambitious dimensions. Throughout this activity, present and proposed, there is nothing essentially new in method of design or construction.

The building art had a momentous experience in the great hurricane that swept southern Florida on Sept. 18. The first wrecking of a steel-frame office building occurred in this storm, at Miami. Unprecedented wind pressure manifested itself, though its amount has not yet been accurately estimated. The nature of resisting action of steel-frame tier buildings was demonstrated in

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this storm in an enlightening manner, likely to lead to important improvement of our methods of design. Prior assumptions of maximum wind pressure, moreover, were shown to be much too low, and the storm effect revealed also that cumulative or sway effect due to wind gusts may have decided importance with respect to structures.

In the details of structural work, the development of a very light rolled I-beam section brought forward the first distinct innovation in the raw materials of the structural industry for many years. Remarkable growth of interest in structural welding took place, which at present outlook is likely to be followed by even greater growth during the immediate future. The year was signalized by two important series of welded tests, one of gas-welded roof trusses and another of a large series of column and beam connections; and by the construction of a large five-story steel-frame manufacturing building with wholly welded connections, completed only a few weeks ago (at Sharon, Pa.).

Bridge Activities

CONSTRUCTION of bridges was almost at the height of activity during the year. No distinct innovations in idea or method characterized this activity, but, on the other hand, a noteworthy increase in size of individual projects is to be recorded. Relatively little was done in the railroad bridge field, but public highway bridge construction was as busy as ever, and private toll bridge construction was phenomenally active. Toll bridges, in fact, have definitely entered into a new phase of vitality, and there are indications that they involve problems which will call for earnest discussion.

The most notable single piece of bridge work during the year was the completion of the Delaware River bridge, a public toll-refunding structure, which a year ago was involved in a bitter dispute between Pennsylvania and New Jersey over the question of free or toll operation. This question was harmonized soon after the new year, Pennsylvania receding from its free-bridge position, and thereafter the final construction operations went forward so rapidly that the bridge was opened July 1, several days before the predicted date. From the start its traffic exceeded estimates, and by the end of the year amounted to more than 4,000,000 vehicles, yielding net earnings (after deductions) of about $950,000.

Other large public bridges under construction are two across Arthur Kill, in New York Harbor, and the Arlington Memorial Bridge across the Potomac at Washington, essentially a pure monument, which may earn the distinction of being the costliest bridge of its size in the world. At New York, also, a quite phenomenal public bridge project has recently been made concrete by the financing of its construction cost; this is the 3,500-ft. suspension span across the Hudson River in the upper end of New York City, connecting with Fort Lee, N. J., a structure which will be just twice as large as the greatest suspension bridge now in existence.

Important private bridges include the toll bridge across Carquinez Straits, near San Francisco, now well along toward completion; the Niagara River bridge at Buffalo, just finished; two Ohio River bridges completed and a third begun, with four or five more in the project stage; one Mississippi River bridge begun, a crossing of Lake Pontchartrain under construction, and a crossing of Mobile Bay. Early in the year Congress adopted a policy as to private toll bridges, and in both sessions of the year displayed great activity in passing private authorizations. A number of projects of unusual size made no particular headway, however, although the Bay bridge at San Francisco, to connect with Oakland, went through a period of very active discussion. There continues to be a definite demand for bridges over a considerable number of major streams, and it is likely that there will continue to be extensive work in constructing these crossings, mainly by private enterprise.

In the railway bridge field, perhaps the most noteworthy enterprise was the rebuilding of the Steubenville bridge of the Pennsylvania R.R., where a series of continuous spans was built around the old simple truss spans, under fully maintained traffic, although change of span length as well as of track level was involved. Opening to traffic of the Central Railroad of New Jersey bridge across Newark Bay during the year put into service probably the most costly railway bridge in the country.

In the field of structural design or assemblage, the continued use of the rigid-frame type of concrete construction in Westchester County, with repeatedly proved high economy, is worth renewed note. The successful use of eyebars as suspension chain members in the Ninth St. and Seventh St. bridges at Pittsburgh, following the pioneer work in erecting the chain of the Florianopolis bridge a year previously, calls attention to this type as an alternative to wire cable construction. It is expected that competitive bids will be asked for wire cable and eyebar chain construction for the 3,500-ft. Fort Lee bridge. On the other hand, the completion of the Delaware River bridge constituted a triumph for wire cable construction, as the 30-in. cables were assembled in remarkably perfect manner and their stress conditions were so fully studied that they are perhaps better known than those of any previous bridge cable.

Cement Study

PORTLAND cement continues to be one of the most important of the engineer's tools. During 1926 close to 170,000,000 barrels were produced in the United States, another record in the unbroken progression of records for each of many years past. Because of the method of distribution through dealers it is impossible to tell just where all of this cement went, nor even to do more than to guess, more or less intelligently, as to the proportion of the various uses. But it all went into concrete, which means that over a hundred million cubic yards of concrete was placed in this country. At a low unit price estimate this means a billion dollars for this one construction material in one year. It merits all of the study that can be given it. Such study progresses, though no radical bit of knowledge was contributed during the year just past.

After long and serious consideration the cement committee of the American Society for Testing Materials, which is the body that really makes cement specification standards, recommended a new standard which was later adopted by the society and is now accepted by most of

the makers and users of cement. This new specification differs from the old in effect only in prescribing a slightly higher tensile strength requirement for the mortar briquette and in making more precise some of the details of testing. The strength requirement adds but little to the quality of cement but the testing improvements are important to the degree in which they are accepted by testers. Reform in testing cement was much needed, for variations in the behavior of cement under test have been shown to lie fully as much in the variations in testing technique as in the quality of the material under test, and cement users were and to a degree still are putting a fictitious dependence upon the assurances of test reports. Portland cement, as turned out by most of the mills of this country, is an admirable product but assurance of its serviceability is not absolutely given by the standard test. To the degree that the new specification is taken seriously by the testers will that assurance be increased.

One of the reasons why the standardizing committee was reluctant to attempt any radical change in specification is the uncertainty that still prevails as to the real nature of portland cement. On that subject the cooperative study by the Portland Cement Association and the Bureau of Standards at the latter institution has progressed during the year. The investigation is of the most complicated sort and planned to extend over a number of years. It is thorough, and it is delving into mysteries which a hundred years of practical use have not yet illuminated. The user and the maker of cement both know that the product is not perfectly suited to the uses to which it is put and they await with interest the results of the research of the scientists at Washington who, so far, have been able to report progress in terms understandable only in the terms of the physical chemist. In time it is hoped that these may be translated into improved quality.

Little New in Concrete

IN concrete 1926 saw less of innovation than for some years past. For a time the discussion as to proper methods of proportioning has lulled, but it is by no means dead. The theory first advanced by Duff A. Abrams, now nearly ten years ago, has the general approval of most of those who have authority in concrete thinking, but the details of that theory as it has been developed both by Professor Abrams and by others in the ensuing years are still subject to much doubt and to much contradiction. In other words, the thought first definitely promulgated by Abrams that concrete strength is dependent on the cement-water ratio is generally accepted. Continuing experiment and trial, however, cast considerable doubt on the theory that certain gradings of aggregate demand certain water-cement ratios to insure the maximum strength. Concrete proportioning under these newer theories is in a much more rational state than it was in the old days of the 1:2:4 concrete. If the newer theories have done nothing else, they have led users of concrete to consider their aggregate, to make test batches and test pieces, and to attempt to reach a rational rather than an arbitrary proportioning of the ingredients that go into the mixture. But there has been a passing of the idea that there was some intricate mathematical performance which could be gone through with any given aggregate which would permit a precise proportioning that would absolutely insure the maximum strength.

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Concrete designing has settled down into somewhat of a routine. There are faint but continued objections being raised by qualified engineers as to the various theories which are accepted as authoritative. Even the generation-old beam theory has not escaped this attack and the newer design principles for columns, especially those advanced in the last Joint Committee report, have been quite vigorously opposed. Most of the concrete, however, continues to be designed by the so-called standard method and most of it, in fact all but an infinitesimal part of it, continues to perform admirably as a structure. Concrete's difficulties are not structural; they lie in its behavior as a material and even then under certain peculiar conditions of exposure. Very little interior concrete is in difficulty. Practically all of the concrete which is subject to criticism is concrete which has to endure the weather, which means moisture under varying temperature conditions. There still remains much to be studied in this field.

Railroad Engineering

CAPITAL expenditures by the railroads during the past year were about equally divided between new equipment and new construction, the latter being made up in a large part by double-tracking and grade revision of main lines and the modernization and enlargement of existing facilities, rather than by the construction of new railway lines. However, a few important new lines have been completed during the year. These include the Southern Pacific's Cascade line in Oregon and its new main line in Arizona and the new lines of Atlantic Coast Line and Seaboard in Florida. Work has been begun on the 175-mile link by which the St. Louis-San Francisco will connect with its isolated Pensacola line and thus get access to another gulf port. Considerable new line construction in Texas is in prospect. The Interstate Commerce Commission in its annual report states that it has authorized the construction of 1,280 miles during 1926.

At the head of a long list of important yard developments are the practical completion of the Markham yard of the Illinois Central, and the Proviso yard of the Chicago & Northwestern, both in the Chicago district. Of a similar character, but on a smaller scale, is the new Ottawa yard forming the Toledo terminal of the Pere Marquette R.R. In yard switching, the introduction of car-retarders or track brakes has given an impetus to the use of gravity switching, but in some large yards a special hump profile permits the classification of cars by gravity without the use of either car-riders (brakemen) or car retarders.

Entire rearrangement of groups of freight terminals of several railroads has been started at Chicago on account of the straightening of the Chicago River.

Railroad electrification has made considerable progress during the year. Besides the installations noted as being in progress at the beginning of last year, those of the Virginian, the Baltimore & Ohio on Staten Island, the Detroit, Toledo & Ironton, and the Illinois Central at Chicago, extensions have been made by the New York Central, the Long Island, and the New York, Westchester & Boston of their electrified zones in the

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New York district. At Philadelphia, the Pennsylvania is making rapid progress with the extension of its electrified zone to West Chester and to Wilmington, Del., and the Reading Co. is considering the electrification of its lines in the metropolitan district but has come to no definite conclusion. In the West, the Great Northern Ry. is changing over and extending its electrified section to the Cascade Mountains. The status of the Lackawanna's frequently postponed electrification around Scranton, Pa., remains unchanged, and that road continues silent about its eastern terminal electrification.

Developments in the field of railroad motive power are dealt with elsewhere in this issue.

The experimental work with roller bearings for freight and passenger cars now being carried out on a number of railroads is of particular interest to civil engineers in view of the possibilities of these bearings for greatly reducing train resistance.

Among the interesting developments in track structures is the announcement that the Pere Marquette is building a quarter-mile section of permanent track having a combined steel and concrete roadbed, as proposed last year by Mr. Alfred, president of the company.

In the matter of safety provisions, the installation of automatic train control devices made a considerable gain during the year. The railroad companies have now had time to study their test sections and are proceeding to extend the installations over additional mileage. The Interstate Commerce Commission reports that up to the first of November 6,495 miles of the 8,368 miles of track covered in its two orders for the installation of train control and 4,582 of the 7,388 locomotives ordered to be equipped have been so equipped.

Highway Advance

HIGHWAY construction continued at the rapid pace it has maintained for several years and bids fair to keep this pace up in 1927. Accurate statistics of construction do not develop until some time later but the data already in hand enable one to estimate for 1926 a total mileage and a total expenditure equal to those of 1925. Specifically, including 5,000 miles graded and drained to engineering standards, there were some 23,000 miles of highway constructed in the year just passed. For the same period the expenditure on road improvement—construction and upkeep—was about $1,300,000,000. Every indication warrants the belief that these figures will be maintained in 1927. Highway improvement in short has become almost the greatest activity in the engineering construction industry. Technically it presented no unusual features in 1926. Recognized good practice in location, design, structure, construction and maintenance was held to more closely and was extended further during the year. The lacking improvement was in administration and consideration of the broad problems of administration as arterial roads, system development, traffic relief, accident reduction and through route service. This in large measure may be attributed to the state of flux in which administrative control of roads finds itself; the merging and readjustment of state and county and township road direction. A multiplicity of local control units hampers broad planning. Today excellent engineering routine characterizes our highway work and the leaven is working toward better administration conditions for taking hold of the broader economic and service problems.

Inland Waterways

ALL those who favor the construction of any one of the numerous inland waterway projects of the country have been much encouraged by Secretary Hoover's advocacy of a vast interconnected waterway system connecting the Great Lakes with the ocean and reaching inland by way of numerous rivers and canals. Mr. Hoover's statements have been so all inclusive and yet so vague in regard to specific projects as to lead the advocates of each project to believe that it has received the endorsement of the Secretary of Commerce. As a result, Congress is being importuned for even more money than usual and the indications are that it will overrule recommendations of the Corps of Engineers against certain projects in order to satisfy this demand, as was done by the House in the case of the deepening of the Missouri River, where the Chief of Engineers recommended against the immediate prosecution of the work. Waterway enthusiasm has a way of being in inverse proportion to transportation knowledge.

Transport Aviation

DURING 1926 great possibilities were recorded for transport aviation. Indeed some years hence the past year may be looked back upon as the real starting point of airway transportation. The passage of the Air Commerce Act in May augurs much for commercial development of transport aviation in the United States. This act asserts the right of the federal government to regulate interstate air commerce, but it leaves to the municipalities and private industry the establishment and maintenance of air ports. The air mail service, now practically accepted as the world standard in civil operation of airplanes, is rapidly being transferred from the post office department to private operators. Although the commercial use of airplanes is much farther developed in Europe than in America because of direct governmental subsidies, there were of the total of nine and a half million miles flown in the world in 1924-25 about two and a quarter million flown in the United States.

The Department of Commerce has planned for 1927 to light for night flying 1,656 miles on seven different routes. Thirty-three intermediate landing fields will also be lighted along these routes. The Coast and Geodetic Survey of the department has begun work on airway strip maps. The Department of Commerce is furnishing information on the design and construction of air port facilities. The Weather Bureau has established during 1926 twenty-two new "upperair" stations along the airways; this is in addition to the regular Weather Bureau offices, the signal corps stations and the navy stations. Air rules requiring registered aircraft and licensed operators went into effect Dec. 31, 1926. Nearly every large city and many of the smaller ones have their airports, most of which are municipally owned.

All this affects the civil engineer and constructor not only as a potential but an imminent source of activity. Airway charting and mapping, location, design

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and construction of emergency landing fields at intervals of approximately 30 miles along all routes, and the major problem of air terminal development touching as it does such other phases as city zoning, economic location, grading, runway construction and location on the field, drainage, proper grass crops, design and construction of such field structures as hangars, beacon and radio towers, warehouses, field markers, repair shops and passenger and freight stations are all problems which are going to assume important proportions when transport aviation receives its share of encouragement and help. The past year marked a beginning.

Traffic and the City

INTOLERABLE is none too strong a term for the street traffic conditions under which most American cities are suffering. Remedial measures are so costly, largely because of the cost of taking land and buildings, as to make it quite beyond the financial abilities of any but the fortunate cities to give more than piecemeal relief. Boston, Detroit, Chicago, and St. Louis are making progress in widening and improving traffic streets. Many smaller cities are also doing good work of the sort. Altogether, these expenditures will soon run into hundreds of millions of dollars. While it is true that conditions demanding these huge expenditures are largely due to a growth of motor vehicle traffic that no one could have anticipated, an examination of the street map of almost any American city will show such a deplorable lack of real planning as was bound to lead to confusion and expense, regardless of how vehicles were propelled. Planning studies of recent years, like the one on "The Providence Traffic and Thorofare Plan," published last December, should contribute largely to the relief of congested traffic conditions, as have the earlier studies at Chicago, St. Louis and the other cities named above. Another contribution to orderly city growth is the United States Supreme Court decision sustaining the zoning ordinance of Euclid, Ohio. This is bound to give an added impetus to zoning everywhere, including cities in the relatively few states in which it had been put under a ban by ultra-conservative state courts. Street widening and other city planning work, including zoning, open up many opportunities for engineers in addition to what they already have had in water-works, sewers, bridges and paving.

Water Supply

ADJUSTMENTS of rival claims on available sources of public water supply, rather than problems of finance, construction and operation, stand in the way of needed water-works enlargements today. These rivalries are not merely between cities desiring the same source of supply but extend to conflicts with owners and users of water for power and with multitudes of people who desire to use streams and lakes for recreational purposes. Added complications oftentimes arise between two schools of water supply: Those who cling tenaciously to the idea that water should be so far above suspicion as to need no treatment to make it hygienically safe and those who are quite willing to use or even prefer treated water. A mixture of these conflicting opinions and interests created a deadlock as regards an additional supply for the Boston Metropolitan District which was at least partly broken in 1926 by the passage of an enabling act directing a construction commission to go to the Ware River for more water and to report to the legislature on the pros and cons of filtration and chlorination of the existing Sudbury and Cochituate supplies. Although these two sources will supply only a small part of the needs of the district the final decision as to their treatment is a matter of much interest in the possible bearing on the Massachusetts tradition against using water needing bacterial improvement. In the case of New York City, the report of the Board of Water Supply, late in 1926, proposing a large new supply to be taken east of the Hudson River, instead of going to the Delaware, appears to be due to delays in working out the proposed tri-state Delaware River treaty. These uncertainties also enter into the question of additional water for the New Jersey Metropolitan District, which is still open. They may have a bearing, although more remote, upon the continued inaction of Philadelphia for additional water. Passing westward to Chicago, the proposed metering and filtration of the supply of that city ties into the interstate controversy over the diversion of Lake Michigan through the Chicago drainage canal. Going still farther west, the proposal of Los Angeles to go to the Colorado River for a huge additional supply hinges on a six-state treaty. A broader view of the utilization of water as a natural resource is being forced upon the attention of water-engineers and the public.

Sewage and Refuse

METHODS of sewage, garbage and refuse disposal have seen no radical change of late. The public is becoming more insistent for treatment where none exists but continues to be indifferent as to how works, once built, are operated. Fine screens for sewage, either as sole treatment for a time or as preliminary treatment, are gaining in favor, as is also chlorination, to deal with bacteria under special conditions. The activated-sludge process is constantly on the gain, but outside of Milwaukee, Chicago, Indianapolis and Houston is in use as yet in only a relatively few rather small American cities. In Canada its spread has been more rapid. The Imhoff tank, with or without sprinkling filters, is still in the ascendancy. Separate sludge digestion is extending. The sewage research work begun forty years ago at the Lawrence Experiment Station of the Massachusetts State Department of Health still goes on and for several years now has been emulated along different lines, at the New Jersey Experiment Station, New Brunswick, N. J., and more recently in Boston under the Harvard School of Engineering. Notable research work on industrial wastes is also being conducted within the industries, particularly on tannery, pulp and paper and cannery wastes. The Isaac Walton League is uniting the piscators of the country to prevent steam pollution, an effort which, if tempered with reason, promises much ultimate good. The whole subject of stream pollution, including a recognition of natural waters as an unavoidable final means of sewage disposal, with or without treatment according to local conditions, needs to be considered broadly.

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Power Development

FIGURES giving the annual increase in the capacity of the country's hydro-electric and steam power plants have been large in recent years, but since this is usual it is passed almost without comment. This year's figures are 525,000 hp. for water power and 1,235,000 hp. for new steam plants—a slight increase over 1925 and about equal to 1924. The public, however, is becoming power conscious. Gradually it is beginning to realize, what engineers have been preaching for years, that more and cheaper power means a better life for the individual, and this realization is making power more and more a political issue. So far neither the impracticabilities of the social worker, the ambitions of the politician nor the crude selfishness of the power financier have forced us into extended public ownership of power but the three together make so pervading a force that anything may happen in the next year or two.

In the field of technical development, a notable event this year was the start of construction on the Conowingo plant on the Susquehanna River where there will ultimately be 600,000 hp. in one plant. The units to go in now will total 378,000 hp., thus making a total capacity greater than in any other plant in the United States except at Niagara Falls. The 54,000-hp. turbines for this plant will be the largest in physical dimensions ever built. The runners will weigh 100 tons each.

In designing settings for reaction turbines there is an inclination away from special or patented draft tubes of complicated form. Such draft tubes are expensive to build and, if patented, the royalty charge added to the increased investment tends to offset any real or fancied gain in efficiency. In one important installation draft tubes of novel design were this year pronounced a failure and were replaced at the manufacturer's expense.

An interesting low-head plant is now under construction at Louisville, Ky., where 8 propeller-type turbines are to utilize a head varying from a normal of 37 ft. to 0 during extreme floods. They are designed to operate over a 27-ft. range of head. The use of propeller type runners increased rapidly during the year. Capacities of these new runners range from small wheels of a few hundred horsepower up to a 31,500-hp. runner for the Manitoba Power Co. plant at Great Falls.

On the West Coast high-head penstocks have this year held the center of the stage of technical interest. Three plants now under construction in California were designed for heads exceeding any thus far developed in the United States. The introduction of banded pipe in the western high-head field is undoubtedly the result of several failures in recent years in welded pipe. Even with banded pipe, in which the welds of the core have been annealed, western engineers are inclined to be very cautious and have insisted on the use of lower working stresses than the manufacturers were willing to guarantee. The development of a greater percentage of steam power on the West Coast is suggested by the increasing economies effected in recently built steam plants where the production has been as high as 400 and 450 kw.-hr. per barrel of oil. This is in contrast to 250 kw.-hr. per barrel that was the standard only a few years ago. With oil at $1.10 per barrel this means a bus bar energy cost of only 5 to 6 mills per kw.-hr. Hydro developments have to be not only well located but well financed and constructed to approach any such low figure as are being shown in steam, as the article on steam power in this issue will show.

Reclamation

MANY vicissitudes affected the federal reclamation enterprise during 1926, in spite of the maintenance of steady and sound administrative policies by the Reclamation Bureau. Early in the year the so-called adjustment law was passed, which remitted $25,000,000 to $35,000,000 of debts owed by the landholders to the government. It was predicted and promised that this would be the last concession that the landholders would demand, and that thenceforth they would pay their obligations regularly and promptly; yet by fall there were insistent demands from their political representatives for postponement of current payments. Improvement in agricultural conditions and insistence by the authorities on payment made the financial showing of the existing projects somewhat better than in recent years, but it became clear that congressmen and senators are still politically minded in their attitude toward reclamation operations in their states. The economic showing of the past quarter century's reclamation thus has not been lifted from its decidedly unsatisfactory condition, and there is every ground for the belief that new irrigation projects of still higher cost per acre are certain to produce huge deficits. Nevertheless Congress again made appropriations for two projects in Oregon, which, after considerable hesitancy, the Secretary of the Interior declared feasible and will shortly begin to construct (Vale and Owyhee), and Congress is about to make an appropriation for the Baker project, also in Oregon, with instructions to the Interior Department that it must build it even though convinced that it will be a losing proposition. It almost appears that the Western members of Congress plan to drag the nation into a new fiesta of lavish expenditures on local development at national expense. Under these conditions, local-district irrigation has not flourished, and particularly in Oregon the condition of districts undertaken within relatively recent years is distinctly bad; a great many defaulted on their bonds after these securities were floated under the misleading state approval and guarantee law which makes them legal investments for trust funds.

While these various incidents have been proceeding in the far West, another move was made toward federal assistance in the salvaging of Southern waste lands. A number of southern tracts available for planned settlement were recently investigated by a federal board, under congressional direction. It appears that some of the southern states clearly recognize the possibilities in such planned settlement, and also that they are aware of their own responsibility in the matter.

A somewhat different development is the undertaking of the San Carlos project, in Arizona, a general irrigation and Gila River regulating scheme carried out ostensibly for the benefit of an Indian tribe. Its novel "multiple dome" storage dam, 250 ft. high, has been given the name Coolidge Dam.

The Engineering Year

Our Relations With Nature

SUMMED up in the word "weather," the manifestations of nature's major forces remain unaccountable. Storms, floods, earthquakes and droughts come as they will, and we have been able so far to make only the vaguest guesses at cyclic or statistically regular occurrence. The year just past has brought its surprises and anomalies in weather. It is true that the great central drainage system—Ohio, Missouri and Mississippi—was quiet, as for four or five years past, without a great flood. But in minor drainages there were unexpected and rather widespread flood conditions, so notably in late summer throughout the Mid-West corn belt, and in December through the central mountain region, where the Cumberland and the Tennessee carry off the principal drainage. We appear to be still in a wet cycle, though probably nearing its end, at least as respects the eastern half of the country. Western weather cycles may lag behind, according to the indications of a new semi-harmonic analysis of meteorological cycles carried out some months ago. Unfortunately there was little activity in flood-protection.

Storm violence made a memorable record in three typical West Indian hurricanes during the summer, the second of which devastated southern Florida (on Sept. 18), while the third (on Oct. 20) swept Havana and barely touched our coast. Scattered tornadoes in locations ranging from Arkansas to Maryland renewed the warning to engineers and builders that great wind violence is of erratic occurrence and may attack—so far as we know—any location.

Earthquakes, too, added to the year's experiences. None of them were of great violence, but the mild repetition of last year's Santa Barbara earthquake, occasional tremors at various points throughout the country, and at the break of the new year a sharp and destructive earthquake along the California-Mexico boundary, continued to remind of the ever-present unrest of the earth's surface. Altogether, the primitive structural concept of static loads and mild wind pressures as a sufficient basis for design is rapidly losing force, and we are coming to understand that unusual disturbances must be reckoned with as contingencies affecting the life and endurance of structures.

Continuing Research

IN civil engineering, discovery and invention are at best minor factors; advance in fundamental knowledge is made either through pushing ahead the frontiers of theoretical understanding of physical happenings or in establishing better correlation between practice and theory. A year ago we had occasion to record steady but uneventful advance of civil engineering research. During 1927 that same history continued. More men and more organizations are engaged in such research now, perhaps, than at any prior time, and the stimulation of research thinking that featured the last seven or eight years grew if anything more pronounced. Little or nothing has been done in engineering theory, and the profession's equipment in this direction seems to be fairly well up to the needs of practice. Correlating applied theory with practical facts engages most of the current study. Engineering Foundation, the Highway Research Board, research promotion in the American Society of Civil Engineers and the American Society for Testing Materials, as well as fruitful work in the engineering laboratories of colleges and of the Bureau of Standards, are making steady contributions to improved knowledge. Increasingly valuable work is being done also by industrial agencies, and it is proper to record for 1926 a distinct growth in the doctrine of industrial research in civil engineering. Among the most noteworthy items is the co-operative study of the constitution and modifying factors of portland cement in progress at Washington through industrial support; but study in paints, clay products, steel structures, lime, masonry, and a large number of other materials and aggregates also is progressing. The two great investigations of stresses in railway track rails and of fatigue of metals are continuing. Structural impact, wind pressure, column strength, arch action, and various questions of applied hydraulics are under investigation. On the whole, belief in the need for research is still on the increase, and the outlook in this phase of professional progress is altogether favorable.

Professional Progress

PROFESSIONALLY engineering must needs move ahead slowly. It is difficult to stop at the end of one year and measure progress. If any one thing is noticeable, however, it is a growing resentment at the low pecuniary reward of the employed engineer, particularly in the service of the various government subdivisions. This took form in Chicago in early summer in a strike of the municipal engineers, and an affiliation of a large number of them with the American Federation of Labor. Similar action is threatened in several other cities, notably in New York where the so-called radicals, that is those who advocate unionism, are making strong effort to control the associations of municipal engineering employees. The problem of the underpaid engineer is complicated and difficult, but neither the New York nor the Chicago move demonstrated that it can be solved by labor union methods. Doubtless complete organization, with the force of affiliated labor behind it, will result in momentary alleviation of the salary difficulty for a few men. It has, however, the balancing detriment of reducing the engineer to the standardization of the hand worker with all the hardship that implies for the individual who would rise. Those engineers who have abandoned hope of elevation and are satisfied to remain journeymen will doubtless be better rewarded as union journeymen, though the many and varied gradations of occupation and reward of the employed engineer lend themselves with difficulty to that essential of unionism, a fixed task and a fixed wage for all. Those engineers whose aspirations are above the standardized mean and who suffer from the current depressed reward must continue, so far as present prospect goes, to fall back on personal initiative which will lead them into other fields of activity. Meanwhile, the organized engineers will have to devote more than their customary routine attention to the problem of forcing upon governing bodies a fair scale of salaries and upon the employing engi-

In Review and Prospect

neer an appreciation of his professional obligation to pay a fair wage for a fair day's work. We must not forget that most engineers are employed.

Engineering societies during the past year did little notable. The American Society of Civil Engineers, for the first time, expelled two members for some unnamed cause, by report a violation of the professional code, thus indicating an awakening of a desire to enforce ethical standards. The society, too, held its four quarterly meetings at four widely separated cities and thereby aroused interest in many more of the members than was possible by the old semi-annual meetings. The technical divisions continue to multiply, and individually to busy themselves, but as yet the society itself has not set itself to that curbing and co-ordinating which is needed to transmute mere busyness into service.

The Contracting Business

AS a business, contracting has experienced a favorable year—construction has been active and prices have been fair, there has been generally good service by railways, materials producers and equipment manufacturers. In the latter weeks of the season continued rain hit road construction a hard blow and turned many a paying operation into a losing one; this indeed has been the dark business cloud of the year. There have existed of course the usual isolated difficulties with labor, irresponsible competition and underbidding, but these are the hazards of the game. Through its organization activities contracting has strengthened its position in the practices of quantity surveying and safety engineering. It has pressed the movement for bonding reform a little further along. Its great advance has been in getting hopeful consideration of a bill holding down day labor construction in federal public works and the adoption of a uniform federal works contract, although only as an active helper is it to be credited with the latter labor. In curtailing day labor undertakings and more particularly in putting the spirit of caution into the undertakings of day labor construction there has been notable progress. The advance in bonding reform has been less pronounced. Yet there have been hopeful conversions among bonding corporations and officials and the pure persistence of the contractors' attack is developing the pressure of growing attention and inquiry by the business public. In its business procedures contracting shows improvement in financing, general accounting and cost keeping and in husbanding its working plant. Its estimating as indicated by bidding prices continues inexplicably erratic. Its great weakness, however, is its selling practices; price controls and price cutting is prevalent, quality of product plays little part in the public's buying of contractors' services. Its organization work is generally better directed and more widespread. Last year the national organization of Associated General Contractors had over ninety chapters actively promoting its national movements besides handling their local problems. Gradually contractors are coming to see the power of such organization as it broadens in membership and learns how to work effectively.

Equipment and Materials

SPECIFIC developments which can be recognized as milestones are, as usual, rare since in reviewing only one year one is afforded too short a backsight. The Mixer Manufacturers Bureau of the A.G.C. made the 10-E paver a standard in place of the 7-E, in order to provide a machine more suitable for curb and gutter construction, alley paving, and similar work. In materials, the Bureau of Public Roads completed an elaborate and successful series of tests on 2½-in. brick with regard to strength and wearing qualities. The use of this thickness of brick has been steadily increasing since 1922, when it was eliminated by the Committee on Simplification for Vitrified Paving Brick of the Department of Commerce; indications point to its reinstatement as a recognized thickness.

Hoist design has tended toward multiple-speed units. Three methods of obtaining slow and fast hoisting speeds stand out—the use of a three-speed sliding gear transmission, similar to that used on motor trucks, the use of two clutches on one drum, and the provision of several sets of sprockets, each with a different gear ratio. In the latter case, moving the silent chain drive from one set of sprockets to another provides the various speeds. Asbestos-faced frictions in place of those made entirely of wood have materially increased.

The use of belt conveyors, both fixed and portable, to replace manual operations in handling materials such as cement, gravel, earth and wet concrete, has shown a definite increase. In several instances belt conveyors have been used to spread stone on large filter beds. Especially notable has been the increase in long portable belt conveyors to upward of 100 ft. length for backfill work in connection with trenching machines.

Changes in the power units of construction equipment have been few. The year, however, saw practically every manufacturer of shovels and cranes offer a Diesel engine as optional equipment; the general acceptance of this type of power for construction machines has not yet been apparent. One manufacturer reports that the production of electrical driven shovels has eclipsed that of all previous years. Much activity has been evident in the production of small shovels of ½ and ¾ cu.yd. capacity.

Refinements in design, as usual, form an important and large part of the progress made. The adoption of roller and ball bearings has increased much more rapidly than in previous years. Heavy steel castings have in some cases replaced cast iron and riveted structural steel. More accurate and rapid water supply systems on concrete mixers have been developed, most of them operating on a siphonic principle.

The rapid progress of welding as a method of structural steel connection has caused increased activity in welding machines. Several new floor joist systems have been developed in the form of trusses made of concrete reinforcing bars with welded connections. A small section light weight I-beam was rolled for the first time during the year, and now is in full production to be used largely for floor joists. Miscellaneous other trends in equipment include increased use of combination lift and force pumps in place of the conventional diaphragm type, the introduction of numerous types of floor gratings, many new models of snow loaders, several types of electric hand saws, and a reduction in the number of sizes and types of the ordinary hand shovel.

One of four articles in this issue recording progress in the allied fields of engineering

Improvement in the Various Types of Railway Motive Power

By EDWARD C. SCHMIDT
Professor of Railway Engineering and Head of the Department of Railway Engineering, University of Illinois

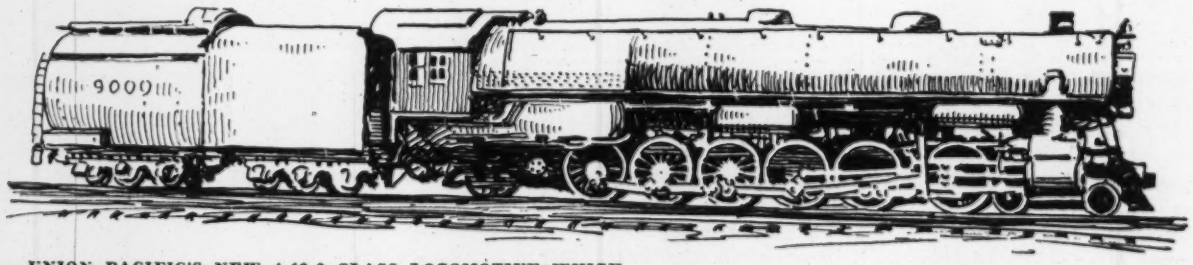
Steam locomotives increase in low-speed tractive effort and in horsepower output at high speeds—Refinements in design reduce fuel consumption—Electric and oil-electric locomotives improved

RECENT development in the locomotives used on American railways, although it presents novel departures and an accelerated rate, follows the usual directions. There has been the usual increase in the maximum tractive force of locomotives in response to the unremitting demand for motive power capable of hauling heavier trains—a demand which has always existed, which proceeds from the desire for greater operating economy, and which has been responsible for the evolution of our numerous locomotive types. The latest response to this demand is Union Pacific locomotive 9000 of the 4-12-2 type, which weighs 495,000 lb. and exerts at low speed a tractive force of 96,650 lb. This is an enormous tractive effort to have been developen within the available space limits and, if we except locomotives of the Mallet type, this is the most powerful steam locomotive yet constructed.

Great tractive force promotes operating economy by reducing the number of trains required for a given traffic. It is possible, however, under some conditions to overdo the increase in train load. On a road with numerous grades the train may be made so heavy that it will move too slowly over the road unless the motive power is able not only to move it on the ruling grade, but to move it rapidly over the numerous lighter grades of the division. This the typical freight engine of ten years ago was rarely able to do. The more recent demand is for a locomotive that is able to haul and to start heavy trains, but that is also able to exert ample tractive force at higher speeds in order to insure rapid train movement. There is a growing realization of the importance of rapidity of freight train movement, of the fact that the tonnage moved per train-hour is a better index of general operating economy than is the tonnage moved per train; and there is consequently a growing demand that freight locomotives shall have greater boiler capacity. A moderate-sized boiler will supply ample steam for the maximum tractive force exerted at low speed, but it cannot supply enough to provide great tractive force at higher speeds. This tendency toward boilers of greater and greater capacity in freight service resembles the long-established tendency in passenger locomotive design, and it proceeds from the same reasons.

The Union Pacific locomotive referred to above as an example of the demand for increased tractive force is likewise an excellent example of the growing demand for locomotives of great capacity and horsepower; for its boiler has 8,413 sq.ft. of heating surface and 108 sq.ft. of grate area; and, as compared with the 2-8-8-0 type Mallet engines which it displaces, it has a maximum speed of 40 miles per hour instead of 20, and an average speed over the district of about 20 as compared with 12 miles per hour.

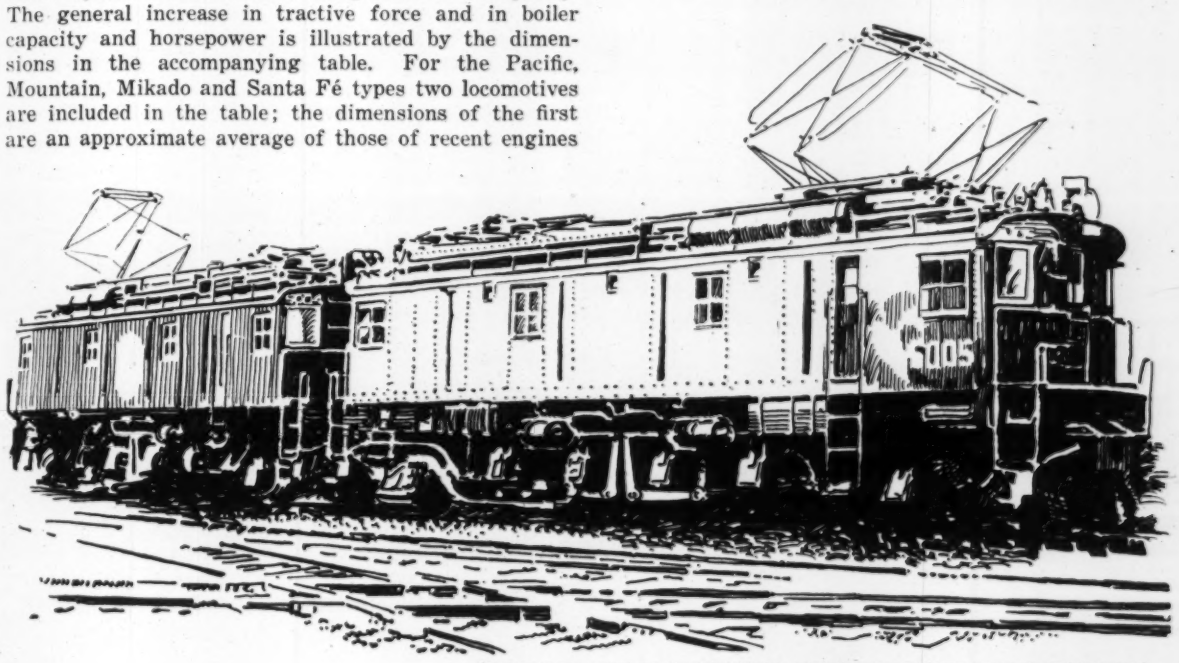
The third demand upon the designer arises from the desire for greater economy in the performance of the locomotive itself—lower steam and coal consumption; and this has been steadily accentuated in recent years by the mounting price of fuel. The response to this demand shows itself in the use of such economy promoting devices as the superheater, the feed-water heater, larger grates, and so forth. It is worth noting that all three of the demands which have inspired motive power development spring from the desire for economy of operation; the demand for greater maximum tractive force and that for greater horsepower both originate in the desire for greater general economy in train movement, while the growing use of locomotive accessories arises either from the same desire for increased capacity or from the need for economy in fuel and water. Every development later to be referred to is a response to one or the other of these demands, and some of these developments satisfy simultaneously two or all three of them.



UNION PACIFIC'S NEW 4-12-2 CLASS LOCOMOTIVE WHICH EXERTS A TRACTIVE EFFORT OF 96,650 LB. AT LOW SPEED

Types of Locomotives

In recent construction the prevailing freight locomotive types continue to be the Mikado (2-8-2) and the Santa Fé (2-10-2); and the desire for larger boilers and grates for these locomotives has led to their derivatives, the 2-8-4 and the 2-10-4 types. In passenger service the prevailing designs are the Pacific (4-6-2) and the Mountain (4-8-2) types. Mountain type locomotives are gradually displacing the Pacifics for the heaviest passenger trains, even on light-grade roads, because of their ability to start such trains easily and smoothly and because of their great boiler capacity. The general increase in tractive force and in boiler capacity and horsepower is illustrated by the dimensions in the accompanying table. For the Pacific, Mountain, Mikado and Santa Fé types two locomotives are included in the table; the dimensions of the first are an approximate average of those of recent engines of its type, whereas the second is the largest or nearly the largest of its type. The horsepower obtained in these modern machines has reached 4,700, which is double the maximum horsepower output for locomotives a decade ago. This is an indication of the success which has been attained in trying to satisfy the second of the demands above referred to, namely, the demand for greater horsepower and greater tractive effort at high speed. For all types of locomotives the tractive effort and the horsepower available in the upper speed range is roughly double what it was for each type ten or twelve years ago.



TWO-UNIT MOTOR-GENERATOR TYPE ELECTRIC LOCOMOTIVE FOR THE NEW ELECTRIFICATION WORK ON THE GREAT NORTHERN RY.

Little Change in Axle Loads

There is no general tendency to increase the total axle load, which remains in the neighborhood of 60,000 lb. This weight is, of course, occasionally exceeded and one locomotive now in process of design will carry 70,000 lb. on each driving axle. Even as early as eight years ago the axle load was carried as high as 73,000 lb., but such loads remain quite exceptional. In the desire to avoid increase in axle load and at the same time to increase the size and the capacity of the boiler, one railroad has recently resorted to the use of alloy steel in the construction of boilers.

One of the most significant recent changes in design, made in the interest of boiler capacity and fuel economy, is a radical increase in the area of the grate accompanied by a corresponding increase in the volume of the combustion space. Until recently, 70 sq.ft. was considered a large grate area, but this area within the last three years has been increased to 100 sq.ft., and in one instance to 108 sq.ft. Such grates permit an enormous coal consumption and steam supply on occasional demand at critical situations on the road, while at the same time they keep the general rate of combustion down at a very economical point during most of the run. Locomotives with large grates and combustion space have amply demonstrated their capacity and economy in long continued service tests. To carry these large furnaces has required the use of a four-wheeled instead of a two-wheeled trailing truck, and this increase in the size of the grates is primarily responsible for the development of the 2-8-4 and the 2-10-4 types, of which 136 are either building or in service on the Illinois Central, Boston & Albany, and Texas & Pacific.

Another important development in general design is the use of limited cutoff in locomotive cylinders. In older locomotives the valve gear permits the steam, upon occasion, to continue to enter the cylinder until the piston has completed about 90 per cent of its stroke. Under these circumstances there is practically no expansion of the steam, which is consequently used most uneconomically. While to be sure this maximum cutoff is used only in starting or on ruling grades, there are come classes of service in which, with these older engines, cutoffs of 70 per cent to 80 per cent are required a good share of the time. Under such conditions the daily steam consumption of the engine may be greatly decreased if the locomotive design is changed so as to provide cylinders of somewhat greater diameter to compensate for the decreased mean effective pres-

sure, while at the same time the valve gear is so arranged that the cutoff cannot be made to exceed some lower limit. This limit generally has been fixed at from about 55 per cent to about 75 per cent of the stroke. General economy in steam is greatly promoted by thus limiting the cutoff and many recent locomotives have been so designed. The resulting economy in steam consumption entails a very considerable increase in locomotive capacity, especially at the higher speeds. In some instances the decreased mean effective pressure has been compensated for by means of increasing the boiler pressure instead of increasing the diameter of the cylinders.

Increased Use of Three Cylinders

There has been an interesting recent revival of interest in the use of three instead of two simple cylinders on the locomotive. Three cylinders have, of course, been frequently used on compound engines, but what is here referred to is the use of three simple cylinders, that is, three cylinders, each of which receives steam at boiler pressure. Three-cylinder engines have been fairly common in European practice and they were used in this country as early as 1878, but they never made much headway here against the aversion to the complication involved by the third cylinder and the cranked axle. They have been revived in American practice within the last four or five years and there are now a considerable number in service. The chief reason for their revival is the fact that for a fixed total weight on drivers the more uniform turning effort obtainable with three cylinders permits the development of greater maximum tractive force than is possible with two cylinders. The three-cylinder machine is inherently less likely to slip the drivers than is the standard two-cylinder engine. Another important reason for their use lies in the fact that with three cylinders the reciprocating weights are smaller and can be better balanced, and the rail stresses due to counterbalance may consequently be much reduced. Because of the smaller cylinder diameter the stresses in the engine parts and in the frame are also much reduced. Furthermore, three cylinders readily permit the use of more economical expansion rates which not only decrease steam consumption, but permit the development of higher horsepower at high speed.

TYPICAL STEAM LOCOMOTIVE FOR HEAVY FREIGHT SERVICE

The steam pressure carried on older locomotives is in the neighborhood of 200 lb. per square inch. Within the last twenty years, however, the boiler pressure has been gradually increased, until we have today in service on American roads about 1,500 locomotives with 250 lb. boiler pressure and a few which carry 265 lb. Increasing the steam pressure is an easy way to secure additional tractive force and power within the available space limits, and it increases steam economy at the same time. The decrease in steam and coal consumed per horsepower-hour effected by even a moderate increase in pressure is so great as to make the use of high pressure a matter of the greatest importance in face of the present price of fuel. These facts account for the great interest in the use of high steam pressure which has manifested itself within the last three years. Within that time the Delaware & Hudson Co. has put in service a locomotive carrying 350 lb. steam pressure and is now building another which will carry 400 lb. In the last year the Baldwin Locomotive Works has built a locomotive with a steam pressure of 350 lb., and the Pennsylvania R.R. is now designing one which will carry 450 lb. On the German State Railways the steam pressure has been pushed even higher. They have recently been experimenting with a locomotive equipped with two separate boilers, one of which carries steam at 200 lb., while the other, which supplies the high pressure cylinders, carries a pressure of 850 lb. All of these engines are three-cylinder compounds and they are distinguished from ordinary locomotives by the fact that their fireboxes are of water-tube construction. It is impossible properly to support the flat surfaces of the standard firebox if the pressure is carried above 300 lb., and consequently radical departures in firebox design have been required for these high pressure machines. They are all experimental and are no doubt subject to further modification in design, but their performance thus far has been encouraging and there is good ground for the belief that we shall soon have numerous locomotives carrying steam pressure in excess of 300 lb. per square inch.

Auxiliary Devices in Use

There is a steadily increasing use of auxiliary locomotive devices designed to promote economy or capacity or both, foremost among which is the superheater. First introduced here on Canadian roads in 1905, the superheater has proved itself to be the most important of all the current developments in locomotive design, and within these twenty years it has been highly perfected. Of the 75,000 locomotives on American and Canadian railroads, about 40,000 are equipped with superheaters. The brick arch is another device whose beneficial effects on combustion and firebox maintenance have come to be accepted as matters of course, and there are now about 53,000 coal-burning locomotives in the United States and Canada equipped with brick arches.

Most modern freight locomotives are of necessity fed by means of mechanical stokers because it is impossible by hand-firing to render fully effective the large furnaces and grates of modern engines. Stokers have made it possible for the designer to satisfy the demand for greater capacity. Of the five prevailing designs, there are now in service on American and Canadian locomotives about 10,250 mechanical stokers. They are also in use abroad, but not in such numbers. Another

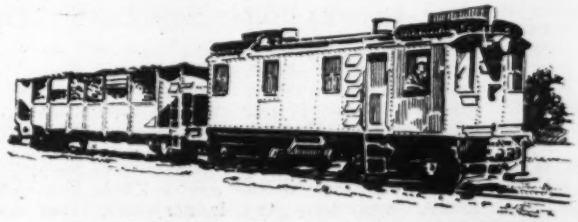
Dimensions of Recent Typical Locomotives

Type of Locomotive	Railroad	Rated Tractive Force Lb.	Weight of Locomotive, Excluding Tender Lb.	Weight on Driving Wheels Lb.	Evaporative Heating Surface Sq. Ft.	Superheating Surface Sq. Ft.	Grate Area Sq. Ft.	Boiler Pressure Lb. per Sq. In.
Pacific 4-6-2	B. & A	42,900	298,000	186,000	4,192	1,163	68	200
	L. & N	47,000	295,000	177,000	3,435	933	67	190
Mountain 4-8-2	C. B. & Q	50,200	368,000	247,000	4,263	1,252	73	210
	D. & R. G. W	75,000	419,000	291,000	5,093	1,495	95	210
Mikado 2-8-2	St. L.-St. Fé	59,800	345,000	262,000	4,047	1,063	70	190
	C. & O	67,700	355,000	272,000	4,461	1,173	80	200
Santa Fe 2-10-2	C. R. I. & Pac	77,800	405,000	318,000	4,940	1,424	80	200
	B. & O	82,800	435,000	345,000	5,251	1,512	88	220
2-10-4	Tex. & Pac	83,000	448,000	300,000	5,113	2,100	100	250
4-12-2	Union Pac	96,650	495,000	355,000	5,853	2,560	108	220

device which has enabled the designer to meet the demand for maximum tractive effort at starting and at very low speed, is the locomotive booster. This is an auxiliary engine mounted either on the trailing truck or on one of the tender trucks and geared to one of the trailing or tender axles, thus utilizing adhesive weight which is otherwise useless. The booster engine is automatically cut out of action when the locomotive cutoff reaches a predetermined limit. Boosters, introduced in 1920, continue to be applied to both old and new power and there are now over 2,600 in service.

Although the feedwater heater has been used on European roads for some years, it has had a long period of probation on American railroads. Two sources of heat are available for heating the feedwater, namely, the exhaust gases and the exhaust steam, and American railroads have experimented with both gas heaters and exhaust steam heaters. The latter, however, have finally prevailed to the exclusion of the former.

Recent progress in the design of steam locomotives may be summarized thus: It is characterized by a continued struggle for greater tractive force and greater sustained horsepower, and by the effort to increase capacity and economy by the use of larger grates and combustion volumes, limited cutoff, the use of three simple cylinders, and higher steam pressure, as well as by the usual resort to such devices as the superheater, the mechanical stoker, the brick arch, and the feedwater heater. The designers' success in realizing these aims is attested by the fact that we now have non-articulated locomotives which develop nearly 100,000 lb. tractive effort, as much as 4,700 horsepower, and which deliver a horsepower for about 16 pounds of steam and less than 2 pounds of coal; and whose thermal efficiency consequently is a little over 8 per cent. This is in many respects an amazing achievement and one from which everyone concerned may justifiably draw great satisfaction. There is, however, another and less encouraging aspect of the situation to which reference ought to be made. The total number of highly efficient and powerful locomotives such as we have been considering, now in operation on American railroads, constitutes a discouragingly small proportion of the total number of locomotives in service.



OIL-ELECTRIC LOCOMOTIVE DEVELOPED FOR SWITCHING SERVICE

Electric and Oil Engines

The fundamental design of new electric locomotives follows in the main the lines already established, although, like the steam locomotives, they become continually more powerful, exceeding the former both in tractive effort and in horsepower. One of the novel developments in this field is a motor-generator locomotive in which the conversion from high-voltage alternating current to low-voltage direct current takes place in a motor-generator carried on the locomotive itself. Eleven such machines are either in use or under construction for three railroads. The year has seen the installation on the Chicago and Northwestern R.R. of the largest storage battery locomotive yet built—a switching locomotive weighing 117 tons.

Because of the absence of standby fuel losses, almost continuous availability, and a thermal efficiency nearly four times as great as that realized by the steam locomotive, the oil engine as a prime mover for locomotives continues to arouse great interest. The construction of Diesel engine locomotives has received great impetus within the last three years, both here and abroad. So far these engines have been produced in small units, the more powerful of the two American types developing only 1,000 horsepower, while the largest one built in Europe develops 1,200 horsepower. Engines of this size are too light for American main-line service and their use has been here confined to yards and branch lines. The locomotives are, however, in their initial experimental stage and units of greater capacity are likely to follow; and then, too, these units may easily be combined as they are in electric locomotives.

On most American Diesel engine locomotives electric transmission is used; that is, the engine drives an electric generator which furnishes current for electric traction motors. In Europe, on the other hand, hydraulic and mechanical transmissions continue to be experimented with — apparently with considerable success. The great advantages of this type of motive power for certain kinds of service make it certain that its development will be vigorously prosecuted and we shall doubtless see its use extended.

Status of the
MAJOR ENGINEERING PROJECTS

Brief statements of the progress made to date on the more important civil engineering developments in the United States and Canada which are either under construction or to be started during the current year.

Hetch Hetchy Water

Work was completed early this year on San Francisco Bay crossing division with a total of 21.8 miles of aqueduct, chiefly 60-in. steel pipe. This is being used temporarily by the Spring Valley Water Co. Work progressing on Hetch Hetchy tunnels in foothill district (below Moccasin Creek power house) on which contracts were let in September for about 7 miles of tunnel. City has also been carrying on tunnel construction with its own forces and altogether 16 miles of tunnels in foothill district are now under way from six construction camps. There is still a gap of about 75 miles of tunnel and pipe line on which no work has been started. This lies between Moccasin Creek power house at the west end of the 18 miles of mountain division tunnels, and the east end of Bay crossing division. If funds for remaining work are forthcoming as needed, it is estimated that the first Hetch Hetchy water can be delivered to the San Francisco peninsula in 1931.

Oakland Estuary Tube

Tube or subway for street cars and vehicular traffic beneath estuary separating Oakland and Alameda, Calif. Being constructed of precast concrete segments built in a drydock 6 miles away, floated to estuary, sunk in place, and concreted into adjoining segments under water. Total length of tube will be just under one mile. Twelve segments being built, dimensions being about 40 ft. in diameter by 203 ft. long and weight 5,000 tons each. Three segments have been sunk in place. Last segment is to be floated from the drydock in January. Construction on tube started early in 1926 and contract calls for completion in July, 1928. However, on Dec. 1, 1926, 73.3 per cent of the work had been done in 52 per cent of the contract time.

Mokelumne Water Supply

Work actively under way on pipe lines and tunnels to bring Mokelumne River water to East Bay Municipal Utility District in California. With a view to possible need for an emergency chlorinated supply from San Joaquin River construction has been concentrated on the 43.5 miles of aqueduct and tunnels between Oakland storage reservoirs and San Joaquin River crossing of the aqueduct. Some 27 miles of 65-in. pipe line with electrically welded longitudinal seams has been successfully laid and much of the line has been tested and backfilled. Work is progressing or has been completed on a total of approximately 19 miles of tunnels and other structures between city of Oakland and San Joaquin River crossing. Contract for Pardee dam at Lancha Plana site on Mokelumne River has been awarded. Some preliminary work is under way on roads and camp buildings and on railroad construction. Work on the dam has not yet been started. Work on the remaining 46 miles of steel pipe aqueduct east of San Joaquin River is expected to start early in 1927 and the delivery of Mokelumne River water into Oakland storage reservoirs is expected in 1929.

Carquinez Straits Bridge

This large cantilever highway structure, a private toll bridge to replace the Rodeo-Vallejo ferry, built by the American Toll Bridge Co., has 3,350 ft. of main bridge (two 500-ft. anchor arms, two 1,100-ft. cantilever spans, and a central 150-ft. tower span), and 1,132 ft. of viaduct approach; clearance height 135 to 156 ft.; three-lane roadway. During the past summer the substructure was completed. Early in the year steel erection was begun, and by 1927 both anchor arms, both land cantilever arms and the central tower had been erected, leaving the central cantilever arms and the suspended spans to be erected. Completion is expected by spring, and opening is scheduled for May 20.

Los Angeles Water Supply

Additional sources of water supply in Owens Valley available for use in Los Angeles are being developed to supplement the present Owens Valley aqueduct. Meantime, engineering studies are being made looking to the construction of the proposed aqueduct that would bring to the city a 1,500 sec.-ft. supply from the Colorado River, a distance of some 268 miles chiefly through desert country. A total of about $2,100,000 has thus far been made available for preliminary work on this project. During 1926 a relief map was built based on topographical surveys made by city survey crews and on U. S. Geological Survey topographical sheets, which shows several routes being considered for the aqueduct. This map is on a scale of 1 in. per mile horizontally and 800 ft. per inch vertically; area included is about 30,000 square miles.

Los Angeles Flood Control

Work has been actively under way this year on several dams included in the Los Angeles County flood control program. Notably Pacoima dam, an arched concrete structure to be 375 ft. high is now well under way. Other structures on which work was done in 1926 were Santa Anita dam, Sawpit dam, and Puddingstone earth-fill dam. Of the $35,300,000 bond issue voted for county flood control in 1924, $25,000,000 was for a dam of unprecedented size on San Gabriel River. Throughout 1926 controversy raged around this proposed structure, the bone of contention being alleged improper location of the dam and interference with needed extensions of Pasadena's water system. A committee of three engineers has been appointed by Los Angeles County Board of Supervisors to review the present program of the county flood control district with respect to San Gabriel River.

Pacific Coast Hydro

Outstanding features of hydro-electric construction on the Pacific Coast in 1926 are the three high-head plants now under way in California. All designed for higher heads than any previously developed in the United States. Aside from the rather large size for impulse wheels in the Big Creek 2-A plant, interest of hydraulic engineers in these installations centers primarily in the penstock. The table on p. 94 gives salient features of the high-pressure portion of the penstocks in all three of these installations.

The Cascade Tunnel

Being constructed under contract for Great Northern Ry. through Cascade Mountains, about 100 miles east of Seattle, Wash. A single-track bore, 8 miles long, being driven by the pioneer bore method and expected to be in granite all the way. It will do away with the present tunnel, 2.8 miles long, which crosses under the pass at a higher level. Work started just a year ago and scheduled for completion late in 1928.

Moffat Tunnel

Rock tunnel six miles long under north shoulder of James Peak, in Colorado, piercing the Continental Divide at El. 9,200 ft. Financed by special assessment system and leased to Denver & Salt Lake Ry. Built by the auxiliary pioneer tunnel method. Work from east end was in solid granite and progressed rapidly until summit was passed, when a heavy inrush of water in February, 1926, delayed progress. Work from west end was in shattered and seamy rock, requiring heavy timbering, which has caused considerable delay. Pioneer tunnel, 97 per cent completed; main headings, 91 per cent; full tunnel section, 79 per cent. Main headings expected to be holed through in March, and tunnel completed by contract date, July 20, 1927.

American Falls Dam

A dam being built at American Falls on Snake River in Idaho to store water for supplementary irrigation of Twin Falls, Minidoka and other tracts and for irrigation of new areas north of Minidoka. The dam is 4,756 ft. long and 60 ft. high, made up of concrete overfall and plain gravity sections and earth embankments. A storage capacity of 1,700,000 acre-ft. is provided. The dam is practically completed and storage of water was begun in October. Cost will be about $1,600,000.

Coolidge Dam

A dam being built across the Gila River near the San Carlos Indian Reservation to irrigate land near Florence and Casa Grande in Arizona. It is to be of a new type called "multiple dome," 249 ft. high and about 600 ft. long, made up of three arch spans curved both horizontally and vertically, the arch spans to be 180 ft. center to center. The contract for the dam was awarded Dec. 2 for $2,268,525. A storage of about 1,300,000 acre-ft. of water is to be provided.

Ohio River Locks and Dams

Improving Ohio River for navigation by providing a minimum channel depth of 9 ft. for its entire length of 968 miles continued through the year by the Corps of Engineers. Consists of construction of one fixed and 51 movable dams with navigation locks having general dimensions of 110x600 ft. at each dam. Navigable passes vary in width from 600 to 1,248 ft. and are closed by wickets of the Chanoine type. All dams between Emsworth, Pa., and Louisville, Ky., a total of 38, have been completed, except for minor details in a few cases, and are in operation. Dam at Louisville being built in connection with development of electric power there. Below Louisville three dams are completed and in operation, eight are under construction, and one has not been started. Total cost of the work estimated at $105,000,000. To date, about $76,000,000 has been spent. Total of 692 miles of the river is now available for navigation.

Illinois Waterway

Link in Great Lakes and Mississippi River waterway for barges; being built by state of Illinois. Length, 63 miles from Chicago drainage canal, at Lockport, to Illinois River at Starved Rock. Marseilles lock completed; Lockport lock 99 per cent completed; Starved Rock lock, 20 per cent completed. The other two locks and the Marseilles diversion canal not yet undertaken. Contract for miter gates for Lockport and Marseilles locks let in August, 1926, for delivery in 1927. Completion of waterway expected by 1930. The provision of a 9-ft. channel in Illinois River from Starved Rock to the Mississippi is a matter for the federal government and not yet authorized.

Welland Ship Canal

Contracts for the last remaining sections of the canal which the Canadian government is building between Lake Erie and Lake Ontario were let last year and the whole project is now under construction. Harbor works at Port Weller and Locks 1, 2 and 3 will be completed in 1927. Work on canal prism and locks 4, 5, 6 and 7, up to the top of escarpment, is about 75 per cent complete with lock work itself about 90 per cent complete. Some portions of the canal south from the flight of locks are completed, other sections about 40 per cent complete. Work at the Port Colborne end is about 62 per cent complete. Bridge work at various crossings is making good progress. During the past year contracts were let for construction of the lock gates. Expected that canal will be ready for use by opening of navigation in 1930. To date $72,300,000 have been spent. Total cost is estimated at $115,000,000.

Detroit Sewage

General approval of the $101,000,000 project for sewer extensions, intercepting sewers, a pumping station and a sewage treatment plant, advised over a year ago by a special commission on recommendation of three consulting engineers, was given by a majority vote of the City Council late in 1926. Treatment includes skimming-detritus tanks, Imhoff tanks and chlorination.

Cleveland Terminal

Union railroad terminal for Nickel Plate, New York Central, and Big Four railroads, and a rapid transit terminal for local suburban lines being built by the Cleveland Union Terminals Co. adjoining the Public Square at Cleveland. To date, all buildings but one have been removed from the site and excavation of the area is 60 per cent completed. About 70 per cent of the piers which carry the west approach over Cuyahoga River valley on a 3,500-ft. viaduct have been built. West of the river, grading for tracks is well under way. Steel construction on the monumental tower which will surmount the terminal is up to the fourth floor.

Muscle Shoals

Work at Muscle Shoals during the year consisted chiefly in minor details of construction and carrying on installation of power equipment. Six of the eight turbines called for in the equipment to be installed at the present time are complete ready for operation, four 30,000-hp. and two 35,000-hp. units; installation of the other two 35,000-hp. units has not been completed. Work on the utility building is well along and construction of the high tension switch yard has been started. The power that is being generated is being sold to the Alabama Power Co. under a temporary contract, a total of over 428,000,000 kw.-hr. were sold in this way.

Alabama State Docks

A port development project by a state commission on a 560-acre site along Mobile River close to Mobile. Consists of five slips, two of which are under construction at the present time, 1,600 ft. long by 350 ft. wide, with piers 516 ft. wide between the slips; transit sheds; a cotton warehouse and railway yard; $10,000,000 was authorized for construction and up to the present $5,000,000 of bonds has been sold. Progress to date includes moving the L. & N. main line inland clear of the site and opening the new canal for industries isolated by closing the 1-mile creek as well as moving of some of the industries; the completion of the reinforced-concrete and steel, cotton warehouse, completion of the apron wharf for pier 2, a reinforced-concrete superstructure carried on concrete piles, and start of work on the apron wharf for pier 1. Considerable dredging has been done and contracts for the transit shed adjacent to the cotton warehouse and on pier 2, buildings of reinforced concrete and steel, will be let in the near future. The cotton warehouse has been put into service.

Conowingo Dam

A 4,800-ft. dam and power house being built near the mouth of the Susquehanna River by the Susquehanna Power Co., a subsidiary of the Philadelphia Electric Co. A total of 378,000 hp. in seven 54,000-hp. units is to be installed in the power house under the present contracts and provision is being made for four more similar units. Work was begun in May, 1926, and it is expected to bring the first units into service during the latter part of 1928. To date excavation and concrete work for the west abutment are practically finished. In the power-house section excavation has progressed to approximately 80 per cent of completion and 13 per cent of the concrete has been poured. About 15 per cent of the tailrace has been excavated. Excavation for the east end of the dam is approximately 65 per cent completed and 75 per cent of the concrete scheduled for the first construction step, namely, all spillway section mats, alternate spillway sections to full height and all bridge piers has been poured.

Philadelphia Subways

Six contracts for construction of 6½ miles of four-track subway from City Hall to Fern Rock terminal yard north of Olney Ave., Philadelphia, and grading of the terminal yard, about 33 acres in area, involving an expenditure of about $57,000,000, have been in progress during the past year and are now substantially completed, about 28 months from the date of breaking ground. Three contracts, having a total length of 3½ miles, are entirely completed, and the remaining three contracts are also completed with the exception of some repaving and minor details of construction. About two miles of Broad St. has been permanently repaved, and additional paving work is under way. Construction is under way on the inspection shop and general repair shop buildings in the terminal yard, and also on two of the three substation buildings required for operation of the subway. The rails and special trackwork for the subway and yard are being delivered, and construction of tracks is under way. One hundred and fifty steel passenger cars for subway operation are under contract for delivery between May 1 and Oct. 31, 1927. Contracts for other subway equipment are now in preparation, and it is expected that cars will be running in the subway by the end of the year.

Philadelphia Terminal

New terminal facilities being built by Pennsylvania R.R. at Philadelphia under an agreement with the city made in 1925. Plans call for a new main station at West Philadelphia to replace Broad Street station, removal of elevated railway from the Schuylkill River to Broad Street station and its replacement by an underground railway to a suburban station just north of Broad Street station, opening up a new street from City Hall along the line of the present elevated railway across the river to the new station, construction of a new office building, and rearrangement of yards and tracks at West Philadelphia. Electrification of suburban lines still operated by steam is an essential feature of the plan but is not specifically included in the agreement. To date, no actual work has been done upon the new terminal other than the construction of the first section of the office building in West Philadelphia which is now practically completed.

New York Water Supply

Additional water supply of 434 m.g.d., from a series of impounding reservoirs on streams east of the Hudson River, was recommended by the Board of Water Supply of New York City late in 1926. The board also renewed its recommendation for a new pressure delivery tunnel from the Kensico reservoir of the present Catskill system through Manhattan Borough and under the East River to Brooklyn Borough. Estimated cost of both extensions is $415,000,000—$348,000,000 for more water and $67,000,000 for the new delivery tunnel. These projects, and also a private proposal to develop 150 m.g.d. from wells on Long Island, were before the Board of Estimate and Apportionment at the close of the year. The Gilboa dam, to store 10 b.g. of water on Schoharie Creek and divert it through the already completed Shandaken tunnel to Ashokan reservoir, was put into service during 1926.

Poughkeepsie Bridge

Highway bridge across Hudson River, being built by State of New York. Suspension bridge of 1,500 ft. main span, two 750-ft. side spans, about 2,000 ft. approaches; clearance height 135 ft. Piers to be sunk by open dredging to about 135 ft. depth. Pier cylinders built and ready to be launched; east approach (1,500 ft. mostly cellular masonry construction) completed. Total cost (excluding land) $6,000,000; present funds $2,300,000; $3,700,000 to be appropriated by present state legislature. To be operated on tolls for refunding state expenditure for construction and county expenditure for land.

New York Subways

Now under contract for new third subway system are 25 sections of the Washington Heights, Central Park West, Eight Ave., Sixth Ave., and Church St. routes, amounting to $118,821,252, and extending from vicinity of St. Paul's church on Fulton St. to the northerly end of Manhattan Island. This will be the main trunk of the system, from which branches will spread out under Harlem River to the Bronx, under East River at 53rd St., Rutgers St. and Fulton St. to Brooklyn and Queens. Contract drawings for Fulton St. (Manhattan) to Cranberry St. (Brooklyn) connection under East River are nearly ready for advertising, and as soon as court action instituted by the Central Park West and Columbus Avenue Association is decided in the Court of Appeals at Albany, the Board will take action toward awarding contracts ($20,209,412) for construction of the 53rd St. route under Welfare Island to Long Island City where the Brooklyn and Queens lines will join. Awards made during the year 1926 are divided as follows:

City's new subway system	$47,736,576
Interborough system	1,526,604
B.-M. T system	5,956,724
Miscellaneous	343,833
Total	$55,563,737

On the new third subway system the contracts range from 20 per cent to 99 per cent complete.

Hudson River Bridge

A 3,500-ft. suspension span highway bridge to be built across the Hudson River in the neighborhood of 178th St., New York, by the Port of New York Authority on a toll-refunding basis. The New York and New Jersey legislatures each have appropriated $1,000,000 to start work and will appropriate each a total of $5,000,000. The Port Authority in December sold the first block of bonds ($20,000,000) of an authorized issue of $60,000,000. The War Department recently approved the mid-channel clearance of 200 ft. as well as approximate location. Plans now being prepared and it is expected that bids will be called for in the near future.

Holland Tunnel

Twin two-lane vehicular tunnels being built under the Hudson River between New York City and Jersey City, N. J. All work on the tunnels is practically completed, except for the installation and testing out of the ventilating equipment. It is expected to have the tunnels in operation early this summer.

Boston Water Supply

Borings are in progress on the line of the Ware River tunnel, construction of which was authorized by Massachusetts Legislature of 1926. Borings were also being made at sites of dams for the proposed Swift River reservoir, authority to construct which has not yet been specifically granted. It is expected that bids will be asked during the spring for the Ware River tunnel, which will be about 12½ ft. in diameter and 12 miles long, and possibly for shaft sinking at an earlier date. The engineer corps, which began work Oct. 1, numbered about sixty late in December. Work is in charge of a special body known as the Metropolitan District Commission. The commission was authorized to build the tunnel already mentioned and to make an early report to the Legislature on the advisability of chlorinating or filtering, or both, the existing Sudbury and Cochituate supplies.

Albany Port Development

Marine terminal for deep draft ocean-going vessels being built on the Hudson River at Albany, N. Y., by the cities of Albany and Rensselaer through the agency of a Port District Commission, in co-operation with the federal government which is dredging the Hudson River to provide a 30-ft. channel as far as Albany at an estimated cost of $11,200,000. Total cost about $20,000,000. Work begun April, 1926, and 300 ft. of bulkhead equipped with cranes and a river depth sufficient for vessels of 14-ft. draft will be ready by July, 1927, and 1,000 ft. of bulkhead, storage space, transit shed and railroad connections by September.

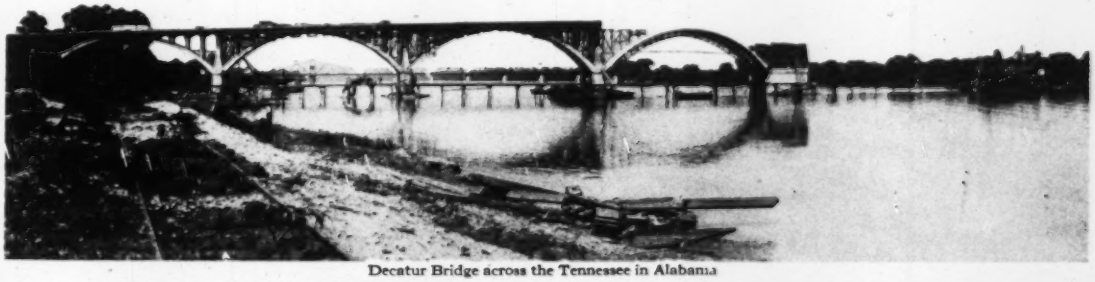
Saguenay River Power

Two more 45,000-hp. units have been brought into service in the Ile Maligne plant at the outlet of Lake St. John on the Saguenay River during the year, bringing the total capacity of that plant up to 450,000 hp. Two units are yet to be installed. Only preliminary work has been done upon the second plant, that at Chute à Caron, which will supply power for the plant which the Aluminum Co. of America is building at Arvida. This plant is expected to have an installed capacity of 800,000 hp.

OUTSTANDING CONSTRUCTION PROJECTS OF 1926

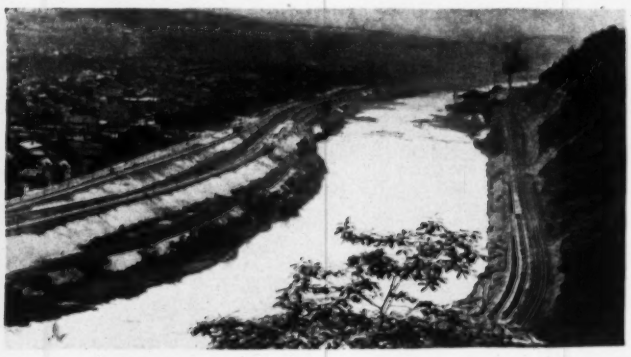
a photographic panorama

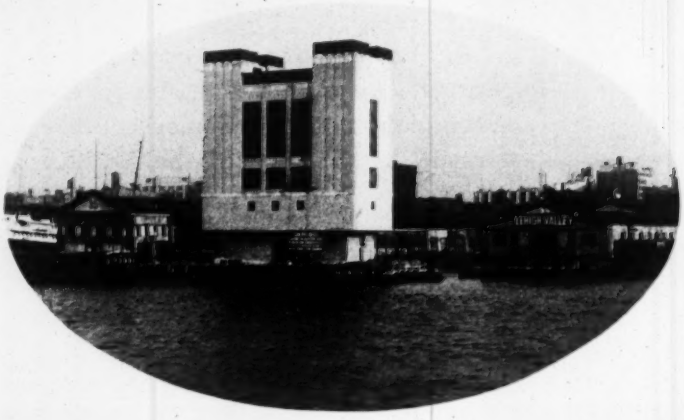
THERE are pictured herewith a number of the principal projects of engineering interest which have been started or finished during the year just passed. Also included are others whose progress toward completion has been marked. No attempt has been made to show all of the major construction operations, but the collection is both geographically and functionally representative of the broad field which *Engineering News-Record* serves. Thus, for example, there are shown a bridge in Pittsburgh, a dam in Alabama, a highway in California, a building in Chicago, foundation work in New York and a sewer in Missouri



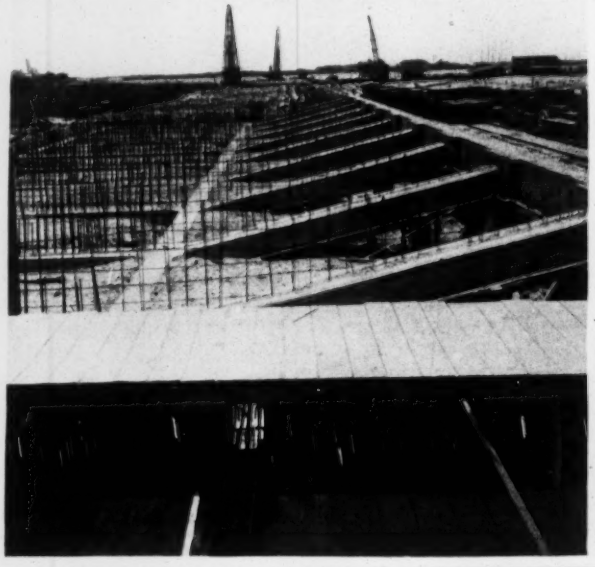
Decatur Bridge across the Tennessee in Alabama

Left: Jewelers Building, Chicago, fronts on the Chicago River; rises 551 ft. above water line and 527 ft. above the upper deck of Wacker Drive. It is 41 stories high. *Below:* Pennsylvania R.R. Relocation: New four-track line on bank of Beaver River, with new river bridge, replaces old line passing through streets of New Brighton, Pa.

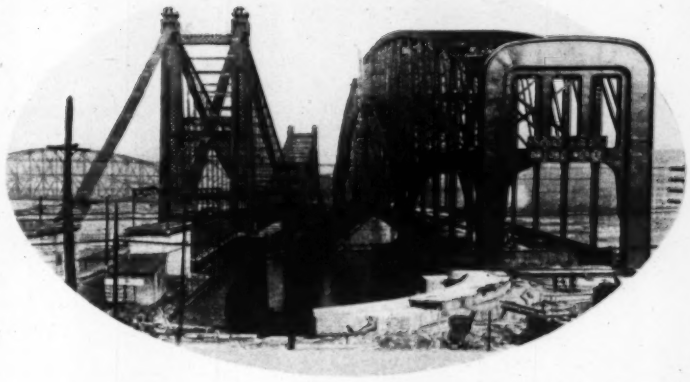




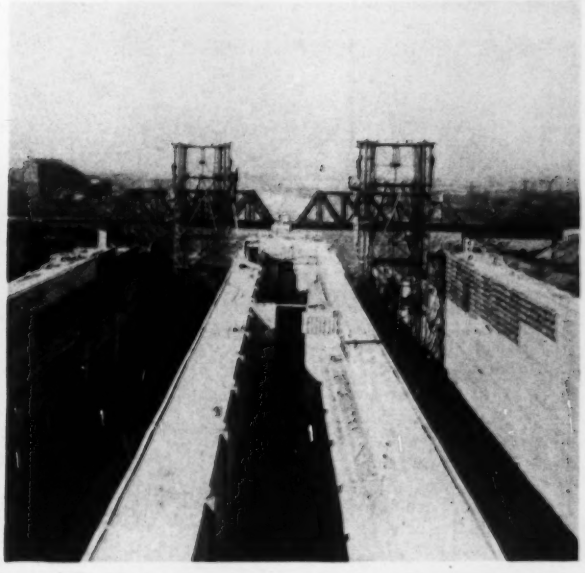
Right: Ventilation building over Manhattan end of Holland Vehicular Tunnel. The building is 110½ ft. high and 136 ft. 10 in. above mean high water. *Lower Left:* Substructure for one of the 560x 1,600-ft. piers of the port development at Mobile, Alabama. The piers are of reinforced concrete. *Lower Right:* Rincon Seawall, on the coast route from San Francisco to Los Angeles built by the California Highway Commission Concrete pavement 30 ft. wide is to be placed during current year.

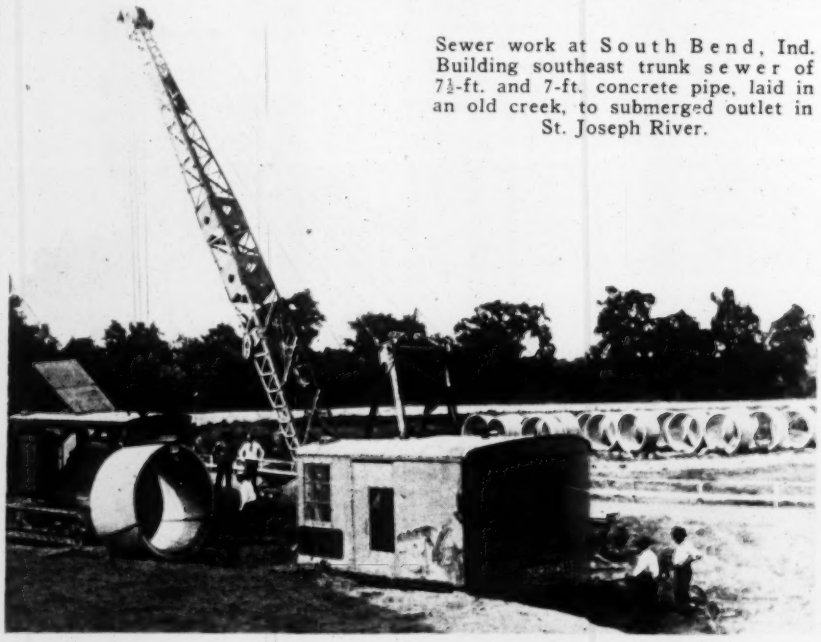


Right: American Insurance Union tower building at Columbus, Ohio. Steel frame structure of 20 stories with 47-story tower rising 555½ ft. above the street. *Below:* Viaduct structure joining Holland vehicular tunnel with New Jersey's arterial highway system. Steel section will connect with a reinforced-concrete double-deck street.



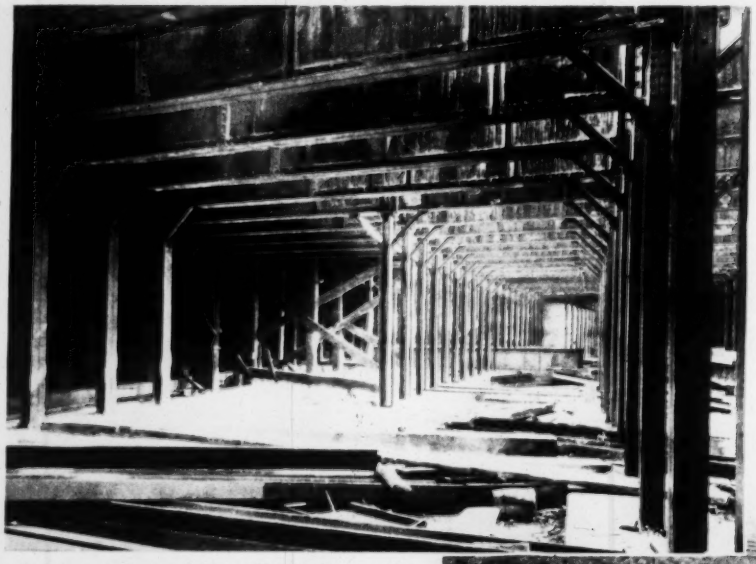
Left: Point Bridge on the Monongahela River, Pittsburgh, is a cantilever structure built to replace a chain suspension bridge. *Bottom Left:* Open section of flood channel, River des Peres, St. Louis, concrete lining carried out to the level of normal annual floods. *Bottom Right:* A pair of locks in the new ship canal being built by the Dominion of Canada between Lake Erie and Lake Ontario to replace the existing smaller canal.





Sewer work at South Bend, Ind. Building southeast trunk sewer of 7½-ft. and 7-ft. concrete pipe, laid in an old creek, to submerged outlet in St. Joseph River.

Present electric operation of old 2½-mile Cascade Tunnel on the Great Northern Ry. is being extended 24 miles west to Skykomish, Wash., with 11,000-volt trolley line and motor-generator locomotives, instead of original three-phase system.



A few sections of New York's new subway along 8th Ave. are nearing completion. Steel bents erected and concreting completed on St. Nicholas Ave. north of 128th St.

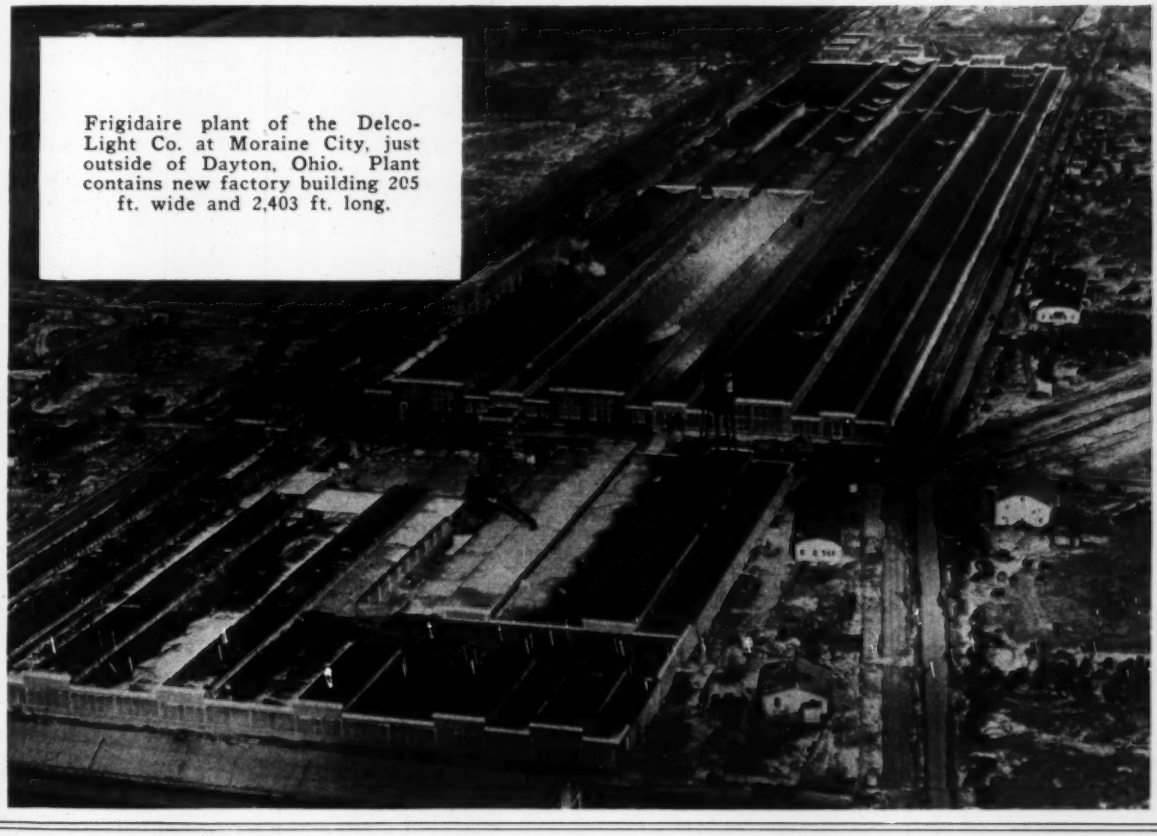
Cahuenga Pass Road is a superhighway built by the city of Los Angeles. It is a concrete road 72 ft. between curbs and 80 ft. over all.

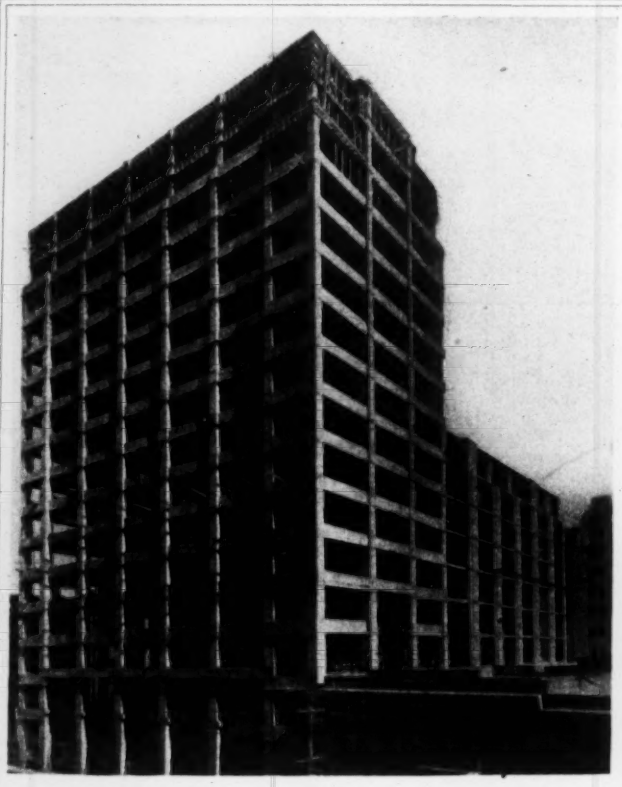
PROJECTS AND STRUCTURES OF 1926

Chelsea Dam, Gatineau River, Quebec, is one of three dams being built by the Canadian International Paper Co. on the lower reaches of the Gatineau River in the province of Quebec, Canada.

The new Cascade line of the Southern Pacific Ry., known as the Natron Cutoff, was opened to traffic in the late summer. It provides a second north and south main line for the railway through Southwestern Oregon.

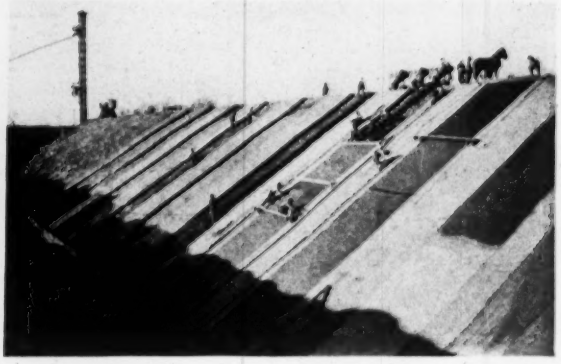
Frigidaire plant of the Delco-Light Co. at Moraine City, just outside of Dayton, Ohio. Plant contains new factory building 205 ft. wide and 2,403 ft. long.





Santa Fe Terminal offices and warehouses at Dallas, Texas. Photograph shows part of the reinforced-concrete buildings which consist in the office building of 20 stories and four warehouses each of ten stories.

Flood Protection at Pueblo, Colo.—Placing cement lining on north levee of relocation of Arkansas River through the city. Channel is 3 miles long for 30 ft. depth of water.

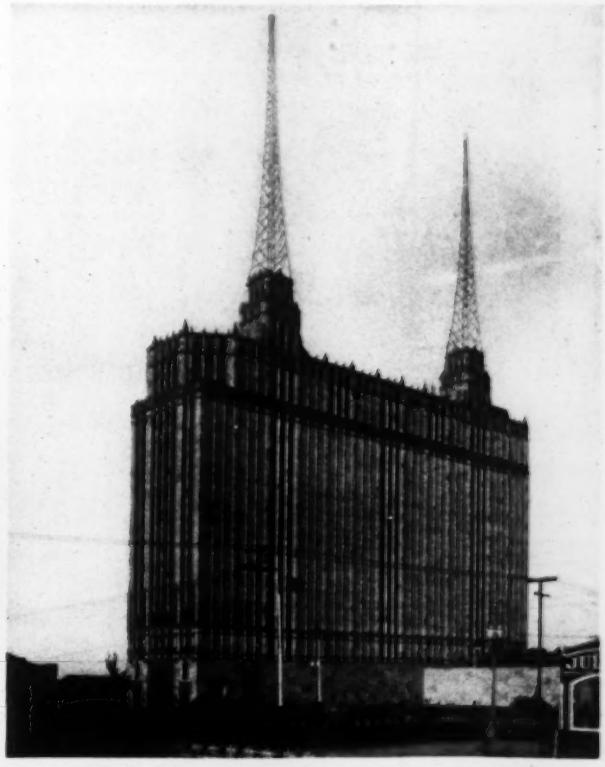


Arlington Memorial Bridge will cross the Potomac between Lincoln Monument and the Lee Mansion, Virginia. Will be the most costly monumental bridge ever attempted; $15,000,000 will be required to complete it.

Lower deck of Wacker Drive, Chicago. Note that the electric lighting is installed in the column heads.

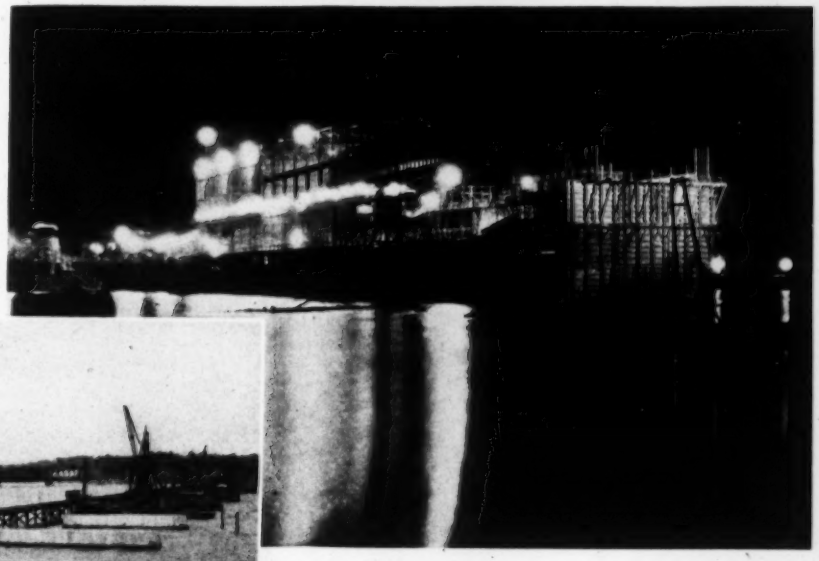
PROJECTS AND STRUCTURES OF 1926

Hollywood terminal in Los Angeles, of reinforced-concrete frame and floors and exterior walls, with portland-cement stucco finish. Tallest building in southern California.



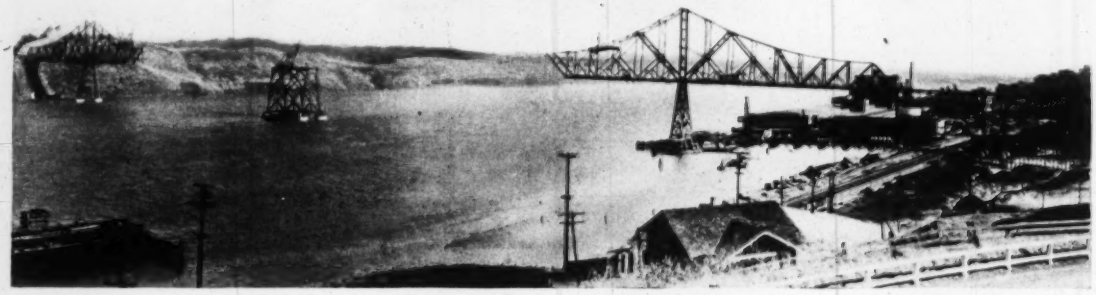
Snake River dam at American Falls, Idaho, just completed. Impounds about 1,700,000 acre-ft. for more complete utilization of the waters of the Snake for irrigation. Federal and private irrigation districts are paying for the work.

Power house being built by the Louisville Gas and Electric Co. in connection with a dam being constructed by the U. S. Government as part of the scheme for improving the Ohio River for navigation.

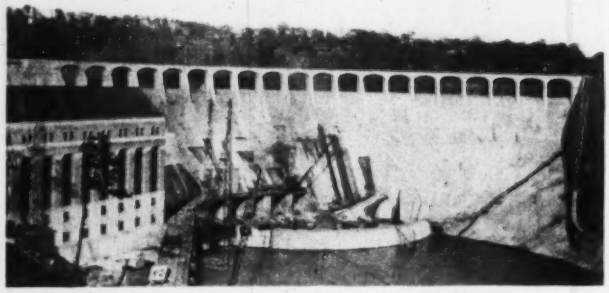


Construction of piers for the long railway bridge across the Mississippi River at Fort Madison, Iowa.

PROJECTS AND STRUCTURES OF 1926

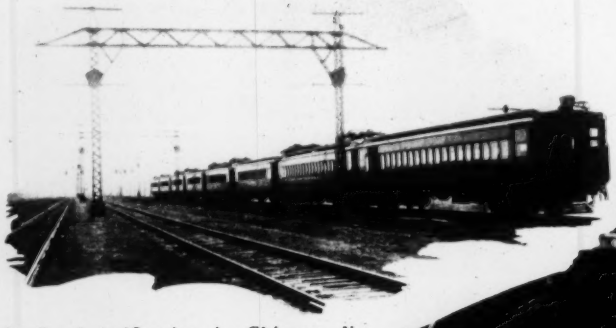


Two-span cantilever highway bridge across Carquinez Straits, California. Pile and open-dredged piers carry two 1,100-ft. spans, each of which will include a central suspended 433 ft. truss.



Martin dam, a combined power and storage project on the Tallapoosa River at Cherokee Bluffs, Ala.

Rail and harbor terminal at Toronto. One of a group of great combined rail and water terminals being built in the port cities of Canada.



I. C. electrification in Chicago district. Eight-car electric suburban train. Catenary structure spanning two tracks and carrying trolley wires over two adjacent tracks.

The site of old Madison Square Garden and the largest open pit job of the year in New York City. An area of 425x198 ft. was excavated to a maximum depth of 72 ft.

Engineering News-Record Annual Statistics of Construction Costs and Volume

THE following seven pages review the business side of construction and, where possible, suggest 1927 probabilities. The first article is a study of contract-volume trend since 1913, based on *Engineering News-Record* statistics. Chart VI on the next page is particularly significant, as showing the improbability of a serious decline in 1927 volume. Any decline is more likely to be in the yearly rate of increase than in actual money value from 1926. A drop of $200,000,000 below the yearly rate of increase would still leave the estimate for 1927 at $2,900,000,000, which is safely above the 1926 total. The third page of this section is the usual presentation of the *Engineering News-Record* Index Numbers of Construction Cost and Volume. This is followed by two pages of charts comparing construction conditions in 1926 with those of 1925. Then appears for the ninth consecutive year, the "Spring Prices" tabulation. Finally, on the seventh page, employment prospects are considered, and a table of wage rates is given covering four trades in four cities from 1913 through 1926.

What Are the Construction Prospects for 1927?

A Prediction Based on Engineering News-Record Statistics of Engineering Construction in the Last Fourteen Years

WHAT has happened is not necessarily a perfect gage of what will happen, but it is one of the bases for prediction. Having that in mind there are submitted herewith certain curves of past performance from which are offered certain guesses as to conditions in 1927.

Road Construction—One of the simplest cases is that of the value of road contracts of $25,000 and more awarded in the United States. Chart I represents the actual yearly totals from 1919 to date with the normal growth line fitted through the prints. The trend is a simple straight line showing on the average an increment of $34,600,000 a year. The actual values follow the trend line so closely that it is possible to predict the amount for next year (barring a war or some other such country-wide disturbing event) with a very high degree of certainty. The mathematical chances are eighty-two out of a hundred that 1927's total will lie between $498,000,000 and $516,000,000. Projecting the trend line back to 1913 shows the same tendency at work but with wider fluctuations from the normal, particularly during the war years when road letting dropped to one-half the normal amount.

Commercial Buildings—Commercial building contracts awarded, of $150,000 and more, illustrate a second kind of growth, as shown in Chart II. The long-time trend line in this case does not show an average increase of a certain amount every year but an increase of a certain per cent of the previous year. There are certain causes at work which would tend to make this true. One is the fact that the population curve follows the same law; another is that the standard of living has been increasing, particularly since the war when so much wealth poured into the United States. A third reason is that the dollar is slowly declining in purchasing value. The fourth reason is inherent in the very nature of the *Engineering News-Record* statistics. These only report commercial buildings of $150,000 and over. The drift from the country to the city means an increase of large apartment houses at the expense of smaller dwellings. This increase of the average value of projects is borne out by statistics of the past three years. In 1924 the average contract value of commercial buildings was $363,000. In 1926 it has been $455,000.

The trend of commercial building shows an average yearly increase of 21½ per cent. The largest deviation has not been much over $100,000,000. This was in 1920, the first year of trying to make up the shortage caused by the war. The outlook for 1927 is that it will equal the 1926 total and will probably exceed it.

Will this curve, or rather can it, continue going up and up at the tremendous rate of 21½ per cent a year?

Is there no end to this tendency? The answer lies in the analysis of the causes that underlie the rate of increase. A slowing up of the growth of population—an event that has already taken place in other countries—a decrease in our standard of living due to depleted natural resources, lower wages, unemployment, etc., the fact that buildings are being constructed to last longer, or a fundamental change in our economic structure such as the introduction of the airplane for commutation purposes; if any of these things happen they will undoubtedly slow up the present rate of growth. But these are causes that work over a long period of time, not suddenly within a year. The accidents that might cause a decline next year are war, restrictive laws or a very serious depression. None of these things seem likely at present. The chances are eighty-two out of a hundred that 1927's amount will be within $125,000,000 of $1,800,000,000.

Public Works—Chart III shows public works which include water-works, sewers, bridges, excavation, drainage, irrigation, etc., but not roads, have been more deeply affected by the war than any other class of construction. It is not until 1923 that it comes back to the normal growth line. Every year since then has shown a uniform increase. No decline in this class is expected.

The amount of money spent by the federal government on construction is the only class that has shown no tendency to increase, see Chart IV. It fluctuates around a yearly average of $40,000,000. The war years, as usual, have to be expected. In 1918 federal construction work jumped to ten times the general average. There may be an increase in 1927 due to the $50,000,000 building program yet to be carried out.

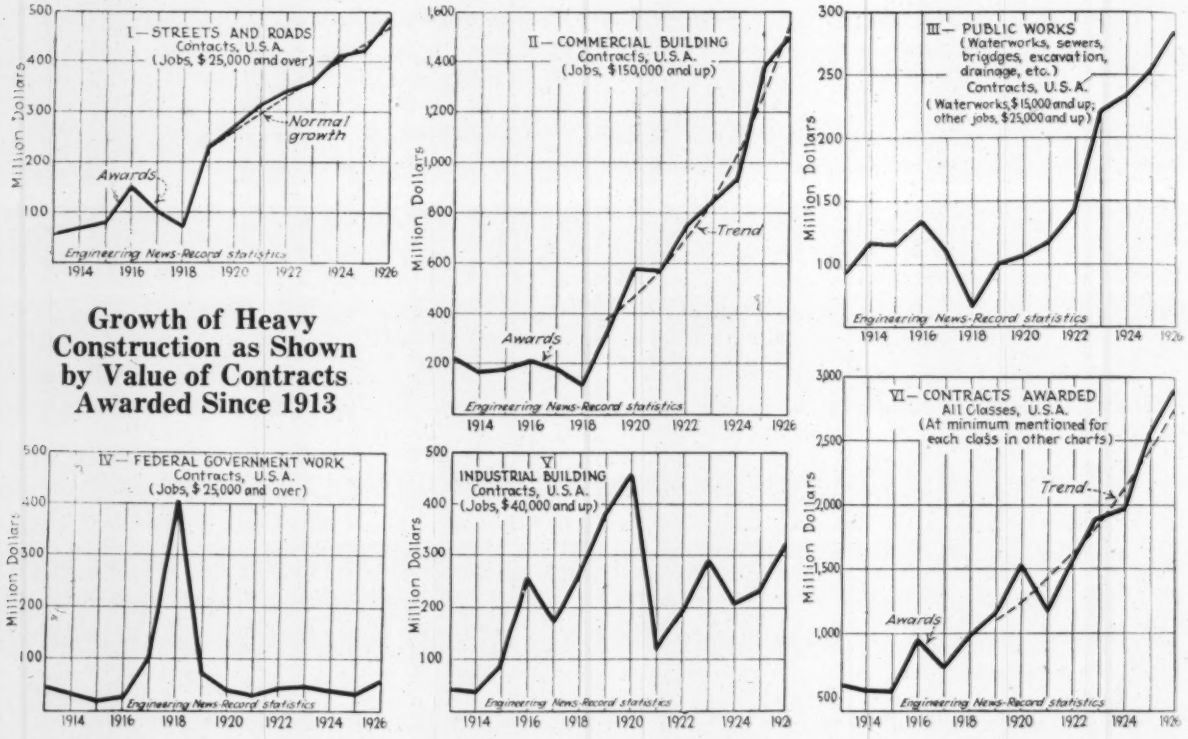
Industrial Building — The industrial building curve (Chart V) shows a definite tendency to increase, but the ups and downs are so violent that a decline in 1927 is as possible as a rise, especially in consideration of the fact that 1926 shows such a big jump, totaling more than any year since the boom of 1920. On the other hand, the volume of production, as recorded by the Federal Reserve Board Bulletin, is bigger than ever and 1927 is just as likely to come up to the 1926 total as even go beyond it.

Heavy Construction, All Classes—The total construction curve (Chart VI) shows a growth similar to that for commercial buildings, except that the rate of increase is not so large, being on the average only 13½ per cent yearly. Here again the evident fluctuations occur in 1920 and 1921—post-war years of readjustment. None of the succeeding years deviate more than 6 per cent from the trend. Both 1925 and 1926 have been about 5 per cent above the normal. This forecasts a decline next year, not in the actual volume of construction but in the yearly rate of increase. A deviation of $200,000,000 below the normal would still bring the estimation for 1927 to $2,900,000,000, which is just above the 1926 total.

All available evidence points to the realization of a volume of construction in 1927, fully as heavy as that for the record year just closed.

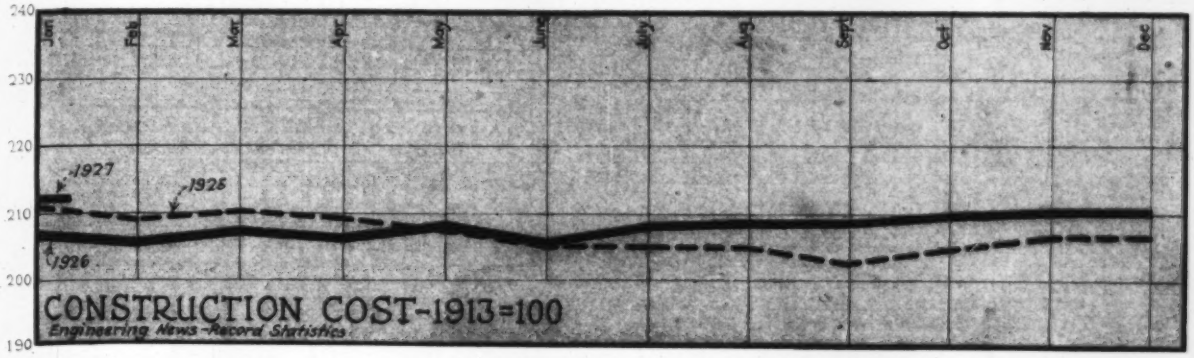
The two classes showing by far the most promising outlook for 1927 are Streets and Roads and Buildings Other Than Industrial.

Mathematical chances are that industrial buildings, public works and utilities, in fact, heavy engineering construction generally, will, during the current year, closely follow the 1926 rate of contract letting.



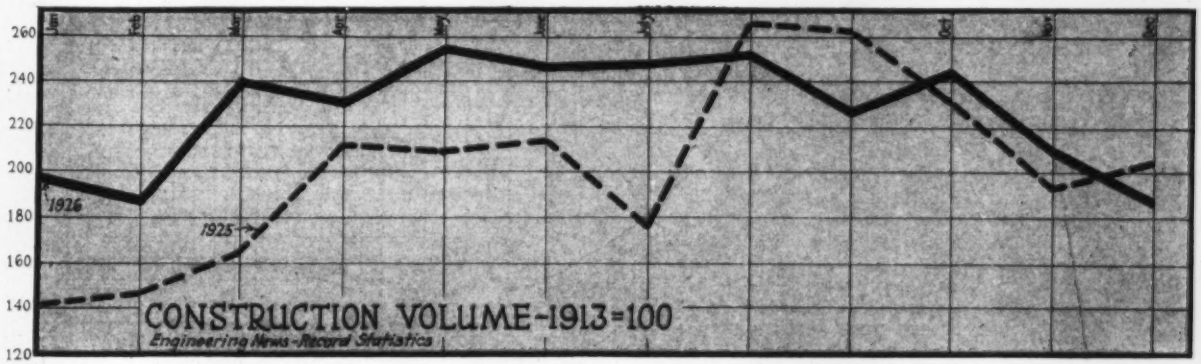
Growth of Heavy Construction as Shown by Value of Contracts Awarded Since 1913

Engineering News-Record Construction Cost Index Number



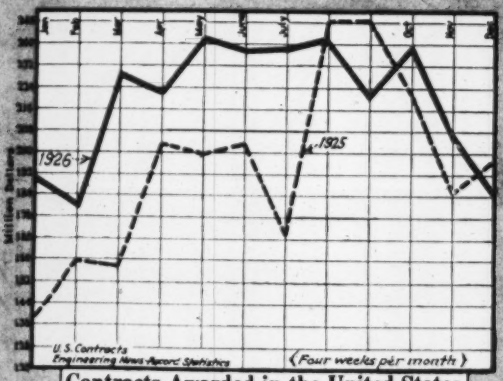
	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
January	89.22	87.12	112.66	167.75	184.51	198.05	206.55	230.87	168.72	191.70	217.90	210.40	207.15
February	89.22	87.36	116.66	167.75	184.51	201.50	225.10	230.67	168.72	197.40	220.30	209.70	206.55
March	88.97	87.66	125.16	175.66	184.51	198.05	240.85	224.27	162.04	205.25	224.70	210.20	207.65
April	87.97	90.16	129.51	183.41	186.01	191.25	265.20	213.07	164.72	213.50	221.60	209.55	207.05
May	88.62	90.16	131.06	187.61	186.01	191.25	268.90	210.82	164.62	216.70	222.38	207.20	207.30
June	87.87	88.96	128.71	199.26	186.31	191.85	273.80	209.82	166.62	220.70	216.85	204.60	204.80
July	88.12	90.51	127.96	204.01	188.65	193.65	265.65	203.82	169.70	222.10	214.40	204.60	207.80
August	90.11	91.76	128.76	198.41	193.85	196.65	252.00	193.47	173.40	221.50	213.15	204.60	208.30
September	90.36	93.01	131.76	190.31	193.85	202.85	255.20	188.27	185.00	221.50	211.25	202.10	208.30
October	88.51	96.16	135.11	167.11	193.85	202.25	255.20	182.57	188.60	220.30	207.55	205.35	209.80
November	87.26	101.06	138.16	166.51	193.55	206.85	255.32	166.32	188.60	220.90	205.70	205.95	210.80
December	86.51	107.06	149.41	167.11	194.75	206.85	251.62	167.82	192.60	217.30	208.58	205.95	210.80
Yearly averages	88.56	92.58	129.58	181.24	189.20	198.42	251.28	201.81	174.45	214.07	215.36	206.68	208.03

Engineering News-Record Construction Volume Index Number

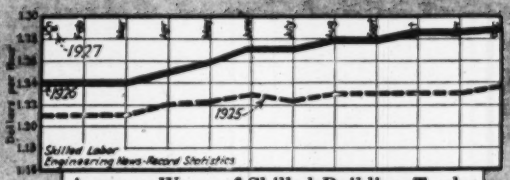


	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
January	71	48	96	69	57	38	138	52	100	151	125	141	198
February	83	76	95	47	151	91	130	55	68	129	144	145	187
March	142	75	90	55	90	52	113	90	186	162	161	161	240
April	113	82	137	65	58	78	134	109	161	186	159	211	233
May	155	96	129	50	67	80	126	108	221	149	191	209	254
June	128	105	129	57	106	129	92	119	178	173	149	214	246
July	139	129	136	87	107	122	83	115	146	151	161	178	248
August	118	126	130	63	111	135	86	116	137	100	162	266	252
September	95	116	145	116	145	113	80	109	149	166	159	262	227
October	108	101	97	87	67	207	79	130	154	154	164	233	244
November	84	150	105	76	66	71	57	106	114	121	128	194	211
December	62	89	106	49	27	41	63	117	134	123	145	206	188
Yearly averages	107	100	119	67	86	98	99	96	147	146	154	201	228

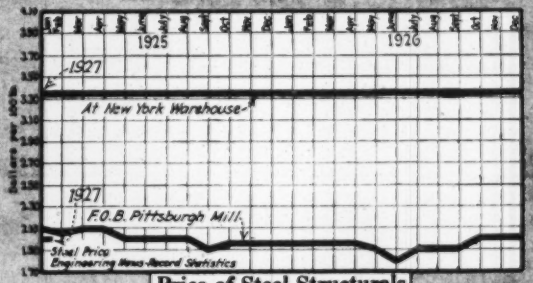
Monthly Statistics of the Construction Industry



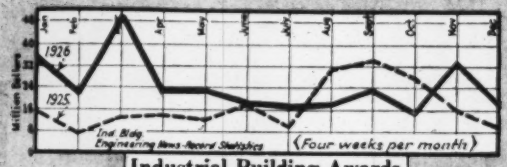
Contracts Awarded in the United States
Reported in E. N.-R.



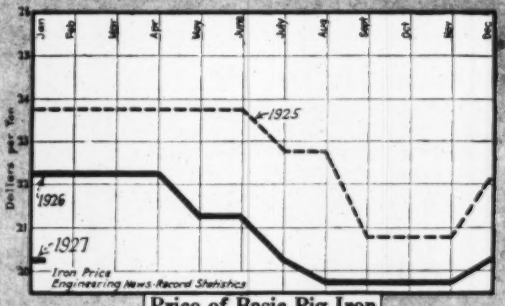
Average Wage of Skilled Building Trades
Bricklayers, Carpenters and Steel Erectors



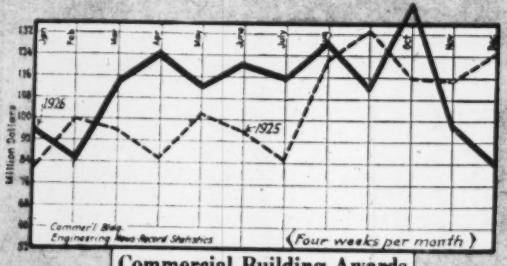
Price of Steel Structurals
Shapes 3-In.; Plates ¼-In.



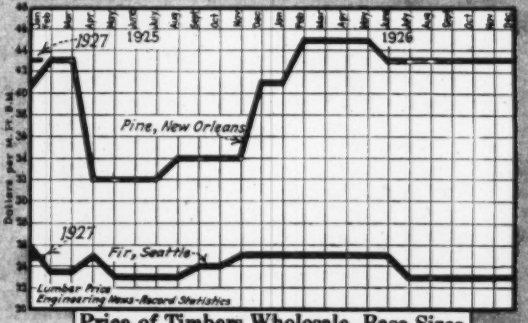
Industrial Building Awards
$40,000 and Over



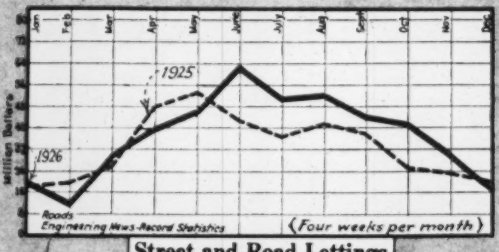
Price of Basic Pig Iron
F.o.b. Pittsburgh



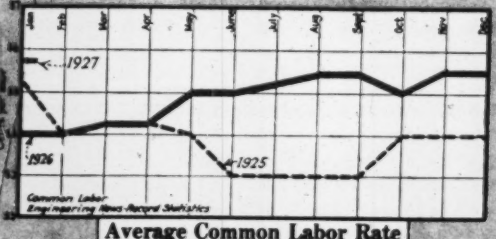
Commercial Building Awards
$150,000 and Over



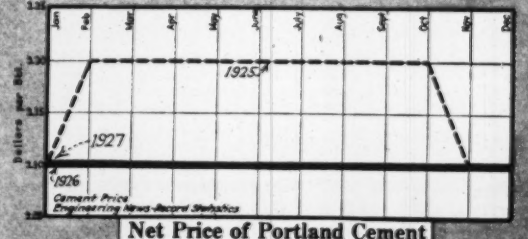
Price of Timbers, Wholesale, Base Sizes
Car Lots to Contractors



Street and Road Lettings
$25,000 and Over

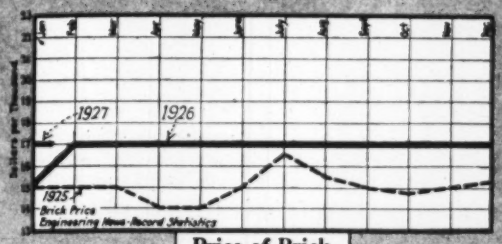


Average Common Labor Rate
Pick and Shovel Men

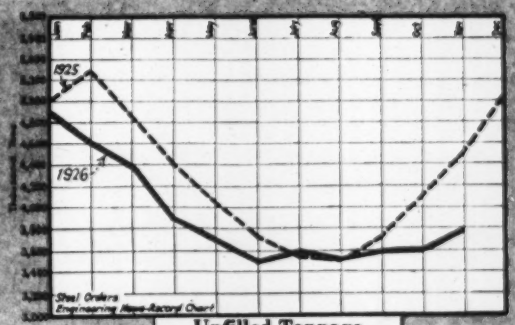


Net Price of Portland Cement
Car Lots, F.o.b. Chicago

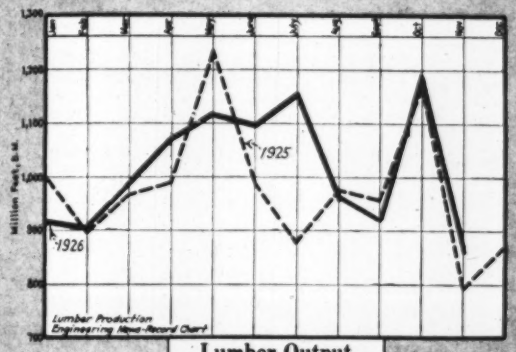
Monthly Statistics of the Construction Industry



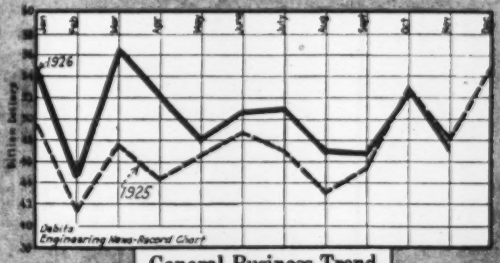
Price of Brick
At Dock, New York



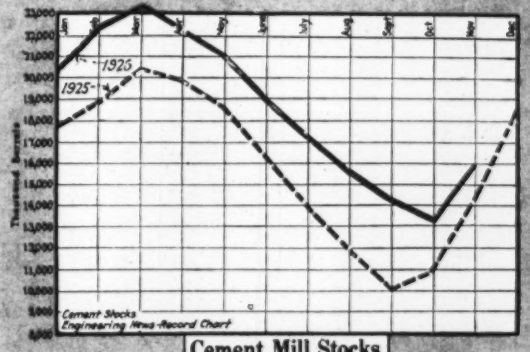
Unfilled Tonnage
On Books of U. S. Steel Corp.



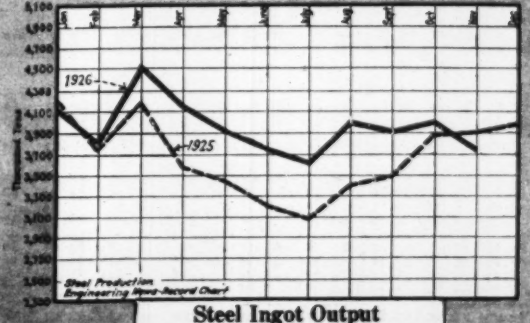
Lumber Output
Nat. Lumber Mfrs. Assn.



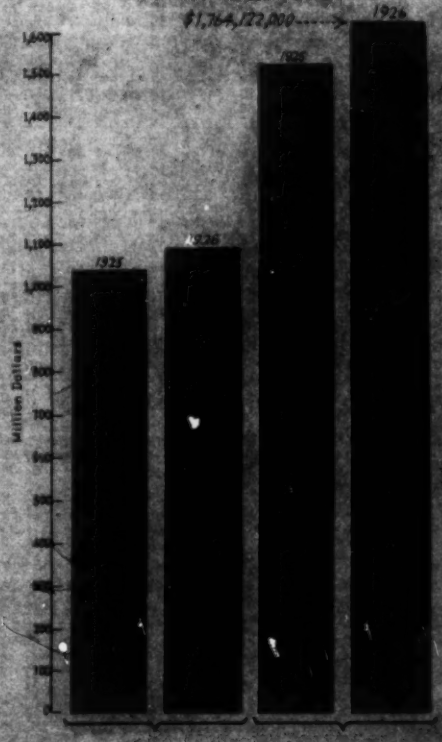
General Business Trend
Bank Debits—Federal Reserve



Cement Mill Stocks
Bureau of Mines



Steel Ingot Output
Gross Tons; Am. Iron and Steel Inst.



Public—Contracts—Private
Jan. 1 to date
Reported by E. N.-R.

Spring Prices of Materials 1913 to 1926

ONCE each year, for the last eight years, *Engineering News-Record* has published the accompanying tabulation of spring construction material prices. This table appears in the first or second issue of January as a rule and shows the cost status in each of the seventeen factors as of April, May and June, each year.

A comparison of current prices with the general average for the fourteen years, shows a gain in most cases, as might be expected.

Declines, however, are found to exist when current steel and linseed oil prices are compared with the general average. Linseed oil (f.o.b. New York) leads the list with a decline of 20 per cent, following that, in order, come steel beams, at Pittsburgh mill, 14 per cent; reinforcing bars, Pittsburgh mill, 11 per cent; steel sheetpiling, Pittsburgh mill, 8 per cent; reinforcing bars at New York warehouse, 2 per cent.

Cost levels as of Jan. 13, 1927, compared with the general average for the fourteen years (spring periods) show the following advances: Common labor, 39 per cent; freight on steel, Pittsburgh to New York, 29 per cent; common brick, 29 per cent; pine timbers, 28 per cent; crushed stone, 25 per cent, hollow building tile, 17 per cent; portland cement, 15 per cent; sand, 9 per cent; gravel, 6 per cent; steel plates at New York warehouse, 5 per cent; steel shapes at New York warehouse, 4 per cent; cast-iron pipe, 1 per cent.

(All Prices F.O.B. New York Except Otherwise Stated)

	Portland Cement, per bbl. net weight, f.o.b. **Chicago**	Southern Pine, 3x12 to 12x12, 20 ft. and Under, per M ft.	Common Brick (per M)	Crushed Stone (per Cu.Yd., 2-In.)	Sand (per Cu.Yd.)	Gravel (per Cu.Yd., 2-in.)	C.-I. Pipe (6-In. per Ton)	Beams and Channels, 3-15-In. per 100 Lb.)	Beams, f.o. **Pittsburgh Mill**	Reinforcing Bars, 3-In. and Larger **Pittsburgh Mill**	Reinforcing Bars, 3-In. and Larger	Steel Sheet Piling, **Pittsburgh Mill**	Tank Plates, 3-In. and Heavier per 100 Lb.	Hollow Tile (10x12x12 per Block), **Factory Perth Amboy, N. J.**	Linseed Oil per Gal. (Raw in 5-bbl. Lots)	Freight to Pittsburgh on Steel (per 100 Lb.)	Average Common Labor Rate per Hr. for U.S.
April, 1913	$1 19	$28 50	$7 00	$0 90	$0 50	$0 85	$24 00	$2 15	$1 70	$1 50	$2 25	$1 60	$1 61	$0 052	$0 48	$0 16	$0 17
May, 1913	1 19	28 50	7 00	90	50	85	23 50	2 15	1 65	1 50	2 25	1 60	1 61	052	50	16	17
June, 1913	1 19	28 50	7 00	90	50	85	23 00	2 15	1 50	1 50	2 25	1 60	1 61	052	48	16	17
Average	**$1 19**	**$28 50**	**$7 00**	**$0 90**	**$0 50**	**$0 85**	**$23 50**	**$2 15**	**$1 62**	**$1 50**	**$2 25**	**$1 60**	**$1 61**	**$0 052**	**$0 49**	**$0 16**	**$0 17**
April, 1914	$1 12	$28 50	$5 50	$0 95	$0 50	$0 90	$22 00	$1 95	$1 15	$1 20	$2 25	$1 60	$1 31	$0 06	$0 54	$0 16	$0 18
May, 1914	1 12	30 00	5 50	95	50	90	22 00	1 85	1 15	1 15	2 25	1 60	1 31	06	54	16	18
June, 1914	1 12	30 00	5 60	95	50	90	20 50	1 85	1 10	1 15	2 25	1 60	1 31	06	53	16	18
Average	**$1 12**	**$29 50**	**$5 55**	**$0 95**	**$0 50**	**$0 90**	**$21 50**	**$1 85**	**$1 13**	**$1 17**	**$2 25**	**$1 60**	**$1 31**	**$0 06**	**$0 54**	**$0 16**	**$0 18**
April, 1915	$1 11	$28 50	$5 50	$0 90	$0 45	$0 85	$20 00	$1 90	$1 15	$1 15	$1 95	$1 60	$1 56		$0 50	$0 169	$0 18
May, 1915	1 11	28 50	5 75	1 05	45	85	20 50	1 90	1 20	1 15	2 00	1 50	1 52		50	169	18
June, 1915	1 15	26 50	6 00	1 05	45	85	22 00	1 90	1 20	1 20	2 00	1 50	1 57		50	169	18
Average	**$1 12**	**$27 75**	**$5 75**	**$1 00**	**$0 45**	**$0 85**	**$20 75**	**$1 90**	**$1 18**	**$1 17**	**$1 97**	**$1 53**	**$1 35**		**$0 50**	**$0 169**	**$0 18**
April, 1916	$1 42	$31 50	$8 50	$0 95	$0 40	$0 80	$30 50	$2 50	$2 50	$2 45	$3 10	$2 50	$2 50	$0 125	$0 81	$0 169	$0 18
May, 1916	1 46	31 50	7 25	95	40	85	30 50	2 50	2 75	2 50	3 25	2 50	2 65	125	81	169	18
June, 1916	1 46	30 50	8 00	95	50	1 00	30 50	2 60	2 75	2 50	3 10	2 50	2 75	125	73	169	18
Average	**$1 45**	**$31 00**	**$7 90**	**$0 95**	**$0 45**	**$0 90**	**$30 50**	**$2 55**	**$2 67**	**$2 47**	**$3 15**	**$2 50**	**$2 65**	**$0 125**	**$0 78**	**$0 169**	**$0 18**
April, 1917	$1 76	$32 75	$9 50	$1 20	$0 50	$1 25	$47 50	$3 75	$3 88	$3 35	$4 60	$3 60	$5 00	$0 185	$1 04	$0 169	$0 28
May, 1917	1 90	34 75	11 50	1 25	50	1 35	55 50	3 80	4 00	3 50		3 60	5 50	185	1 21	169	28
June, 1917	1 91	39 75	10 25	1 25	50	1 25	55 50	5 00	4 31	3 50	5 10	3 60	7 00	185	1 31	169	28
Average	**$1 86**	**$35 75**	**$10 40**	**$1 25**	**$0 50**	**$1 30**	**$51 70**	**$4 15**	**$4 06**	**$3 45**	**$4 85**	**$3 60**	**$5 80**	**$0 185**	**$1 19**	**$0 169**	**$0 28**
April, 1918	$1 96	$42 75	$10 25	$1 75	$1 25	$2 00	$55 35	$4 20	$3 00	$2 90	$4 09½	$3 10	$4 45	$0 20	$1 55	$0 195	$0 37
May, 1918	1 96	42 75	10 00	1 75	1 25	2 00	55 35	4 20	3 00	2 90	4 09½	4 00	4 45	20	1 55	195	37
June, 1918	2 00	43 25	10 25	1 75	1 25	2 00	61 35	4 20	3 00	2 90	4 09½	4 00	4 45	20	1 58	195	37
Average	**$1 97**	**$43 00**	**$10 15**	**$1 75**	**$1 25**	**$2 00**	**$57 35**	**$4 20**	**$3 00**	**$2 90**	**$4 09½**	**$3 70**	**$4 45**	**$0 20**	**$1 56**	**$0 195**	**$0 37**
April, 1919	$2 00	$45 00	$15 00	$1 75	$1 25	$2 00	$57 70	$3 47	$2 45	$2 35	$3 37	$2 55	$3 67	$0 2263	$1 55	$0 27	$0 46
May, 1919	2 00	45 00	15 00	1 75	1 25	2 00	57 70	3 47	2 45	2 35	3 37	2 55	3 67	2263	1 63	27	45
June, 1919	2 00	46 00	15 00	1 75	1 25	2 00	52 70	3 47	2 45	2 35	3 37	2 55	3 67	2268	1 76	27	45
Average	**$2 00**	**$45 50**	**$15 00**	**$1 75**	**$1 25**	**$2 00**	**$56 03**	**$3 47**	**$2 45**	**$2 35**	**$3 37**	**$2 55**	**$3 67**	**$0 2264**	**$1 65**	**$0 27**	**$0 45**
April, 1920	$2 00	$72 00	$18 00	$2 00	$1 25	$2 25	$72 30	$5 00	$4 00	$4 00	$5 00	$3 65	$5 00	$0 4263	$1 87	$0 27	$0 55
May, 1920	2 08	70 00	18 00	2 15	1 50	2 50	76 30	5 00	4 00	4 00	5 00	3 65	5 00	4263	1 87	27	57
June, 1920	2 15	70 00	18 00	2 15	1 50	3 00	76 30	4 47	4 00	3 75	5 00	3 65	4 67	4263	1 73	27	58
Average	**$2 08**	**$70 50**	**$18 00**	**$2 10**	**$1 42**	**$2 58**	**$74 97**	**$4 83**	**$4 00**	**$3 92**	**$5 00**	**$3 65**	**$4 89**	**$0 4263**	**$1 83**	**$0 27**	**$0 57**
April, 1921	$2 17	$48 00	$16 00	$1 95	$1 25	$2 50	$63 30	$3 33	$2 00	$2 00	$3 28	$2 55	$2 00	$0 2055	$0 73	$0 38	$0 56
May, 1921	2 17	48 00	15 00	1 95	1 25	2 50	63 30	3 33	2 20	2 10	3 38	2 55	2 40	2055	67	38	57
June, 1921	2 17	43 00	14 50	1 95	1 25	2 50	58 30	3 33	2 20	2 10	3 38	2 55	2 40	2055	80	38	58
Average	**$2 17**	**$46 25**	**$15 00**	**$1 95**	**$1 25**	**$2 50**	**$61 60**	**$3 33**	**$2 15**	**$2 10**	**$3 35**	**$2 55**	**$2 25**	**$0 2055**	**$0 73**	**$0 38**	**$0 57**
April, 1922	$1 97	$44 00	$16 25	$1 75	$1 00	$1 75	$47 30	$2 48	$1 50	$1 50	$2 58	$1 75	$2 48	$0 2105	$0 83	$0 38	$0 43
May, 1922	1 97	43 00	17 00	1 75	1 00	1 75	47 30	2 58	1 60	1 60	2 68	2 00	2 58	2105	91	38	42
June, 1922	1 97	43 00	20 00	1 75	1 00	1 75	49 30	2 58	1 60	1 60	2 68	2 00	2 58	2105	91	38	43
Average	**$1 97**	**$43 33**	**$17 75**	**$1 75**	**$1 00**	**$1 75**	**$47 97**	**$2 55**	**$1 57**	**$1 57**	**$2 65**	**$1 92**	**$2 55**	**$0 2105**	**$0 88**	**$0 38**	**$0 43**
April, 1923	$2 20	$58 00	$20 00	$1 75	$1 00	$2 25	$57 50	$3 44	$2 45	$2 35	$3 34	$2 50	$3 44	$0 2905	$1 13	$0 34	$0 50
May, 1923	2 20	60 00	20 00	1 75	1 25	2 25	58 50	3 44	2 50	2 40	3 34	2 60	3 44	3505	1 16	34	51
June, 1923	2 20	60 00	20 00	1 75	1 25	2 25	63 00	3 64	2 50	2 40	3 54	2 65	3 64	3505	1 16	34	53
Average	**$2 20**	**$59 33**	**$20 00**	**$1 75**	**$1 16**	**$2 25**	**$59 66**	**$3 50**	**$2 48**	**$2 38**	**$3 40**	**$2 58**	**$3 50**	**$0 3305**	**$1 15**	**$0 34**	**$0 51**
April, 1924	$2 20	$59 00	$20 00	$1 85	$1 25	$2 00	$62 60	$3 64	$2 45	$2 40	$3 54	$2 65	$3 64	$0 2442	$0 95	$0 34	$0 54
May, 1924	2 20	58 00	20 00	1 85	1 25	1 75	62 60	3 59	2 38	2 33	3 49	2 45	3 59	2786	95	34	56
June, 1924	2 20	54 00	20 00	1 85	1 00	1 75	62 60	3 59	2 28	2 25	3 49	2 38	3 59	2786	98	34	56
Average	**$2 20**	**$57 00**	**$20 00**	**$1 85**	**$1 16**	**$1 82**	**$62 60**	**$3 60**	**$2 37**	**$2 32**	**$3 50**	**$2 49**	**$3 60**	**$0 2671**	**$0 96**	**$0 34**	**$0 55**
April, 1925	$2 20	$56 00	$15 00	$1 85	$1 00	$1 75	$53 10	$3 34	$2 05	$2 15	$3 24	$2 20	$3 34	$0 252	$1 14	$0 34	$0 54½
May, 1925	2 20	55 00	15 00	1 85	1 00	1 75	53 10	3 34	2 00	2 00	3 24	2 20	3 34	252	1 07	34	54
June, 1925	2 20	54 00	15 50	1 85	1 00	1 75	51 00	3 34	2 00	2 00	3 24	2 28	3 34	252	1 09	34	53
Average	**$2 20**	**$55 00**	**$15 17**	**$1 85**	**$1 00**	**$1 75**	**$52 40**	**$3 34**	**$2 02**	**$2 05**	**$3 24**	**$2 23**	**$3 34**	**$0 252**	**$1 10**	**$0 34**	**$0 53½**
April, 1926	$2 10	$57 00	$17 00	$1 85	$1 00	$1 75	$51 60	$3 34	$1 95	$2 05	$3 24	$2 27½	$3 34	$0 252	$0 83½	$0 34	$0 54½
May, 1926	2 10	57 00	17 00	1 85	1 00	1 75	52 60	3 34	1 95	2 00	3 24	2 27½	3 34	252	84½	34	55
June, 1926	2 10	57 00	17 00	1 85	1 00	1 75	52 60	3 34	1 85	1 90	3 24	2 27½	3 34	252	84	34	55
Average	**$2 10**	**$57 00**	**$17 00**	**$1 85**	**$1 00**	**$1 75**	**$52 26**	**$3 34**	**$1 92**	**$1 98**	**$3 24**	**$2 27½**	**$3 34**	**$0 252**	**$0 84**	**$0 34**	**$0 55**
General average	$1 83	$44 95	$13 19	$1 55	$0 92	$1 65	$48 05	$3 20	$2 33	$2 24	$3 31	$2 48	$3 17	$0 2148	$1 01	$0 263	$0 40
Jan. 13, 1927	$2 10	$57 50	$17 00	$1 94	$1 00	$1 75	$48 60	$3 34	$2 00	$2 00	$3 24	$2 27½	$3 34	$0 252	$0 81	$0 34	$0 55½

Prospects Favorable for Employment of Construction Labor in 1927

MORE than 80 per cent of the important industrial centers of the country enter 1927 with a reasonable assurance of tranquillity in the construction labor market. Most of the cities in which wage demands are forthcoming will not face the emergency much before March or even May of the current year.

The movement for the five-day week assumes increasingly serious proportions as the new year gets under way. The idea is equivalent to a demand for higher wages schedules, since the hourly rate must be increased in order to correspond to the weekly earnings now being realized by the mechanics. In accordance with this process, over-time would raise the weekly labor cost to a level even higher than it is at present.

In the accompanying table average yearly labor rates are shown at four strategic points, in the key trades, for the years 1913 to 1926, inclusive.

The outlook for employment of construction labor in several large cities is briefly outlined as follows:

New York—The 1926 building total for this city came very close to the billion dollar mark, small jobs included. The gain over 1925 was approximately 3 per cent. All five boroughs showed declines in total number of buildings, while all but one, Manhattan, realized gains in money value of projects.

Combined with construction other than buildings, the 1926 grand total shows a greater number of contracts awarded than in any year since 1920.

Following are some of the big jobs proposed during the last two months: High schools, Bd. of Educ., $3,000,000; bakery and office building, National Biscuit Co., $3,000,000; Jewish hospital, $2,200,000; playground, Jacob Weiss Park, $2,000,000; hotel, 150 Riverside Dr. Corp., $1,500,000; warehouse, A. J. Morgan, $1,500,000; four apartments, aggregating $7,250,000.

Chicago—Construction program for 1927 promises to equal, if not slightly exceed, that of the last year. Many large structures will be built, among them a bank and office building for the State Bank of Chicago, $5,000,000; Medinah Athletic Club, $6,000,000; Criminal Court, administration building and jail for Cook County, $7,500,000; office and theatre building, for 23 W. Monroe St. Bldg. Corp., $6,000,000; office and store building for Pancoe Bros., $3,500,000; Theatre, hotel and stores for A. Karsas, $5,000,000; Shedd Aquarium, $3,000,000.

Labor is well employed with no strikes or disturbing influences as to wage increases in sight, while building material costs promise very little change from current levels.

St. Louis—Construction in the St. Louis territory, including Eastern Missouri, Southern Illinois, Arkansas and Southern Iowa, during 1927 is expected to compare very favorably with 1926. In Missouri there will be some falling off in state road construction, but this will be offset by increased activity on strictly county and local projects. Arkansas and Iowa will experience increases in that respect, while the $100,000,000 bond issue in Illinois will stimulate local projects in that state.

In St. Louis there will probably be fewer large apartment houses and hotel projects than in the year just closed, but this is more than offset by several large municipal projects and some large office buildings. The result will be that, on the whole, the year will show an increase in volume over 1926, but not quite up to the record set in 1925.

Large projects on which contracts are scheduled for letting during 1927 include: $8,900,000 in various buildings; a $4,000,000 Civil Courts building; a $5,000,000 Municipal auditorium, and a $3,500,000 theatre and office building for William Fox Film Co. Labor rates are expected to remain on present levels and no serious labor troubles are anticipated for the new year.

Pittsburgh—Some sizeable projects are scheduled for 1927, namely, the Cathedral of Learning (University of Pittsburgh), valued at $10,000,000; Pittsburgh Medical Center Group $10,000,000; Post Office and Federal Building, $5,000,000; Allegheny General Hospital, $6,000,000; and other buildings amounting to about $3,000,000.

Birmingham—The year 1926 was one of the very best building years Birmingham had ever experienced but contractors and builders are predicting that the year 1927 will surpass it.

There are no labor troubles of any kind in the vicinity and there are no indications of strikes during 1927. Everything favors a big building volume for the current year. A construction program of nearly $22,000,000 is contemplated. Paving and sewer work alone will cost $6,000,000.

Cincinnati—Prices and labor rates remain steady. The building program for 1927 amounts to considerably over $6,000,000.

Wage Rates Per Hour in Building Trades—Yearly Averages 1913 to 1926, Inclusive

	New York				Chicago				St. Louis				San Francisco			
	Brick-layers	Hod carriers	Car-penters	Struc-tural Iron-workers	Brick-layers	Hod carriers	Car-penters	Struc-tural Iron-workers	Brick-layers	Hod carriers	Car-penters	Struc-tural Iron-workers	Brick-layers	Hod carriers	Car-penters	Struc-tural Iron-workers
1913....	$0.70	$0.375	$0.625	$0.625	$0.75	$0.40	$0.65	$0.68	$0.70	$0.4875	$0.625	$0.625	$0.875	$0.50	$0.625	$0.75
1914....	.75	.375	.625	.625	.75	.40	.65	.68	.75	.4875	.625	.65	.875	.50	.625	.75
1915....	.75	.375	.625	.625	.75	.40	.65	.68	.75	.4875	.625	.65	.875	.50	.625	.75
1916....	.75	.375	.625	.66	.75	.425	.70	.68	.75	.4875	.625	.675	.875	.50	.625	.75
1917....	.75	.45	.69	.68	.75	.45	.70	.69	.75	.4875	.65	.70	.875	.50	.68	.75
1918....	.81	.45	.69	.80	.75	.50	.70	.70	.85	.51	.70	.80	1.00	.625	.75	.875
1919....	.875	.575	.75	.875	.875	.575	.80	.875	1.00	.6375	.825	.925	1.125	.75	.875	1.00
1920....	1.25	.775	1.125	1.125	1.25	1.00	1.25	1.25	1.25	.70	1.00	1.25	1.25	.93	1.06	1.175
1921....	1.25	.875	1.125	1.125	1.25	1.00	1.25	1.25	1.25	.85	1.25	1.25	1.25	1.00	1.125	1.25
1922..	1.25	.876	1.125	1.125	1.10	.725	1.10	1.05	1.25	.85	1.10	1.06	1.25	.71	1.04	1.125
1923....	1.50	.95	1.125	1.125	1.10	.725	1.25	1.05	1.50	1.00	1.25	1.25	1.375	.77	1.04	1.125
1924....	1.50	1.00	1.3125	1.29	1.35	.725	1.17	1.25	1.75	1.20	1.525	1.45	1.25	.8125	1.00	1.125
1925....	1.50	1.00	1.3125	1.4675	1.50	.825	1.3475	1.36	1.75	1.20	1.50	1.50	1.25	.8125	1.00	1.125
1926....	1.645	1.07	1.45	1.60	1.56	.88	1.39	1.405	1.75	1.20	1.50	1.50	1.25	.8125	1.00	1.125

One of four articles in this issue recording progress in the allied fields of engineering

The Motor Bus As a Means of Highway Transportation

By CARL W. STOCKS
Editor, "Bus Transportation," New York City

A little of its history—Its growth and development with figures as to present day operation—The industry regulated in 38 states and not tax free—Outlook for future full of optimism

JUST what is bus transportation? What is its sphere of operation? Is it serving a real need?

It hardly seems necessary to define it when buses are to be found on almost every improved road in the country, linking sections heretofore often without adequate regular transportation.

What is its sphere of operation? In general, operation can be said to be divisible into three parts: (1) common carrier service, i.e. over regular routes on fixed schedules; (2) transporting children to improved and consolidated schools; (3) sightseeing, tourist and party service.

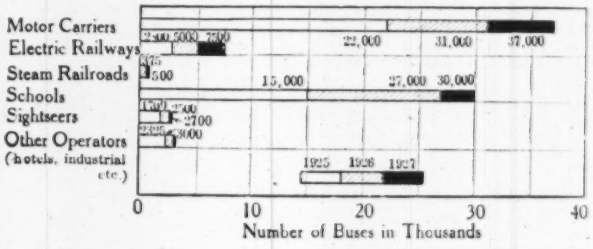
Is bus operation serving a real need? Perhaps this can be best demonstrated by indicating to what extent the bus has established itself as part of the whole transportation system.

Some idea of the present magnitude of the industry can be gained by the fact that over three billion people in the United States are carried in buses yearly; that bus routes cover 352,000 miles of highway—this is compared with the 250,412 miles of steam railroad and the 43,933 miles of electric railway track. Thus there are more miles of route covered by buses than by the steam and electric railways of the country combined, and, extensive as bus operation is at present, the general consensus of those interested is that its usefulness has only just begun.

What types of service do the buses render on the highways? The most extensive is, of course, the common carrier. This term signifies operation on a definite schedule over a regular city, intercity or interstate route. Then there is the non-common carrier, which includes service rendered by schools in transporting pupils; by hotels carrying guests to and from railroad stations or golf clubs; by sightseeing companies operating special trips in territories of historical or scenic interest; by tourist organizations carrying passengers on all-expense trips of from 1 to 14 days' duration; by factories and industrial plants in transporting employees to and from their work.

Who operates the buses? First, there is the motor carrier, meaning by that term the operator who is in business for himself and not allied with another transportation agency. Then there are the electric and steam railways that run buses in connection with or in lieu of certain parts of their rail systems, or to open new territory. These three classes of carriers run all five of the types of service previously mentioned. The growth in bus operation by each of them within the past few years is shown in the accompanying chart. The extent to which steam railroads have entered the field has been an outstanding development of the year 1926. The New England Transportation Co., a subsidiary of the New York, New Haven and Hartford R.R., for instance, is now operating 170 buses over 1,100 miles of route in the states of Connecticut, Rhode Island and Massachusetts, while the Boston & Maine Transportation Co., a subsidiary of the Boston & Maine R.R., has 60 buses—

TOTAL NUMBER OF BUSES OPERATED BY PRINCIPAL CLASSES OF CARRIERS
As of Jan. 1, 1925, 1926-1927



with more on order for new planned routes— on 338 miles of route in Massachusetts, New Hampshire and Maine. The Great Northern R.R., through its subsidiary the Northland Transportation Co., operates a majority of the intercity bus lines in Minnesota, and is one of the most extensive bus operators in the United States. The Santa Fé System, operating through the Santa Fé Transportation Co., carries passengers from its trans-continental line by bus to scenic points in New Mexico, in addition to operating three intercity routes either supplemental to or substitute for rail service. The Baltimore & Ohio R.R. has established passenger terminal facilities in New York and Brooklyn with bus service from its railroad terminal in Jersey City, N. J.

The Trend in Vehicle Design

The development of the present-day motor bus from the diminutive five-passenger touring car, which first made its appearance on the Pacific Coast in 1914, is an interesting story. While riding on a modern bus with its low center of gravity, pneumatic tires, comfortable and commodious seats, and well illuminated and heated interior, it is difficult to realize that the development of the bus idea is traceable to the use of private automobiles for handling short-haul city traffic. Following the appearance of the jitney, so-called, the urge to ride on

rubber spread in two or three years over almost the entire country, and as the business grew in popularity the vehicle grew in size. First there was the lengthened passenger chassis, and then the truck chassis, each capable of carrying bodies of larger passenger capacity.

At this time the chassis manufacturer, except in a few instances, paid but little attention as to how the consumer used his product, with the result that in the period 1914 to 1921 a marked difference had grown up in the type of single-deck vehicles for service in the Eastern and Western part of the country.

The Eastern operator had developed a body more like the street car, with a front entrance service door and seats arranged along a central aisle for short-haul local city service, whereas the Western operator had enlarged on the touring car type of vehicle for the longer hauls in cross country intercity service, and had put a separate entrance for each row of seats. The sedan type of bus, with its individual seat entrances, and doors closing on the running board, was an outgrowth and was originally developed by a Pacific Coast manufacturer in 1922. Soon after came the parlor car type of bus now so popular.

IN THE REDWOOD COUNTRY ON AN INTERCITY BUS

With the steady increase in demand for bus service continuing, the manufacturers of motor vehicles were not long in taking up the idea that a bus was not a truck, and that if bus travel was to be made attractive the vehicles must have the same appeal as to riding comfort found in the private automobile. Hence came the use of longer and more flexible springs, shock absorbers, longer wheelbase, double overstuffed upholstered seats or individual seats and later the balloon tire.

It was in the fall of 1920 that the first attempt was made to build the low floor type of city bus. Heretofore the one-ton and the speed-wagon type of truck chassis had been generally used. Of course, in New York City, the Fifth Avenue Coach Co. had long stood out as the most conspicuous example of local bus operation, but then as now these buses were for the most part on solid tires.

Originally put out for sightseeing purposes, in 1906, double-deck buses have long since passed that limited use, and are now recognized by transportation men as having possibilities for handling even mass transportation.

The present trend in vehicle design indicates that small capacity parlor cars, seating 17 to 21 passengers, are rapidly gaining in favor for intercity and suburban service. There is also evident a tendency, especially in the case of the large 29-passenger single-deckers, to adopt a union of the parlor car and city type design even for use in city operation. The gasoline electric bus has likewise found favor in certain quarters, especially in urban service where the stops and starts are frequent. Its progress is being carefully watched by the entire industry.

The demand for luxury of travel, for comfort and for speed has increased the weight of the modern bus. Actually, bodies have become nearly double in weight in the last five years. Chassis weights likewise have been increased as the severity of service has been recognized by the manufacturers. Five years ago a 22-passenger intercity sedan type bus weighed 6,700 lb. while the modern 29-passenger parlor car has a weight of 10,700 lb.

Characteristic weights and dimensions of the several types of present-day buses are given in the accompanying table. Naturally tire sizes have increased to keep pace with the greater weights. At one time single tires were the rule—with sizes running as high as 40 x 8 in. These large sizes have since been supplanted with duals, that is, two tires per wheel, in sizes 36 x 6, 34 x 7 or 36 x 8 to secure larger road bearing surfaces and to lower the center of gravity of the vehicles.

Do buses destroy the highways? A popular idea exists that they are highly destructive. It was implanted in the public mind during the World War when roads which had been built for lighter vehicles were destroyed by the trucks put in service by the army, when the railroad embargo was in force.

Thomas H. MacDonald, chief of the U. S. Bureau of

Some Salient Dimensions of Buses that Use Our Highways

Type	Weight (Pounds) Chassis	Weight (Pounds) Body	Length (Inches, Dash to Rear)	Tire Sizes (Inches) Front	Tire Sizes (Inches) Rear (Duals)	Gages (Inches) Front	Gages (Inches) Rear
Light duty (10 to 18 passengers)	1,475– 5,400	1,500– 3,400	131¾–209	30x3½	32x6	55¾–62	55¾–70
Medium duty (18 to 25 passengers)	3,270– 6,200	1,500– 4,400	113 –240	32x6	36x6	56 –66	56 –73 9/32
Heavy duty (25 to 43 passengers)	4,800– 8,975	2,300– 5,500	207 –300	34x7	36x6	56 –77¼	56 –80
Double-deckers (55 to 67 passengers)	6,850– 10,350	5,190– 9,308	201 –293	34x5	36x8	67 –74	72 –80

Public Roads, in an article published in *The Journal of Land & Public Utility Economics*, Oct. 1925, had this to say on the subject: "Roads can be built to carry vehicles of any weight, heavy or light; and so long as the designed load is not exceeded there will be no destruction. Roads will wear out as steel rails wear out, and motor trucks and tires wear out. But they will not be destroyed; and whether the relatively heavy loads be few or many there will be no appreciable difference in the rate of wear. The first essential is to fix the maximum vehicular weight. That has been done by law in all states. The next is to build roads to carry the maximum load. That is being done. The third is to enforce the legal weight restrictions. Where these three essentials are properly observed, there will be no destruction; and the only appreciable result of the increase in the design load will be an increase in the cost of construction."

Regulation a Reality

It is often said that the bus is allowed to run wild on the highways with very little regulation or official supervision. In the light of this statement it is interesting to note that several thousand laws affecting the bus have been passed by state legislatures.

Today motor buses in common carrier service are regulated by state laws in 38 states. The usual practice is to require those who desire to operate buses in intercity or city service to obtain from the state regulatory body a certificate of convenience and necessity and, in most states, file an indemnity bond or insurance policy covering personal injuries and damage to property. In a few states also they are required to obtain permits from each community through which they pass. The regulatory bodies also have power in some states to supervise rates, schedules and service; to require that property and equipment be kept in proper condition; and to require systems of accounts, annual reports, and notices of accidents.

MOTOR BUS OPERATING BETWEEN PHILADELPHIA AND WASHINGTON

In 13 states there is no restriction as to the width of buses. Twenty-six states restrict the width to 96 in. In Florida and Louisiana buses cannot exceed 84 in. in width; in Maryland, Nebraska, Oklahoma, South Carolina, Texas and West Virginia 90 in., in North Carolina 86 in., and in Rhode Island 102 in.

The speed of buses is regulated in all but two states. The speeds set as maximum vary with the tire sizes, the type of service in which the bus is engaged and the like. In 22 states buses cannot exceed 35 m.p.h.; in 18 states speed is limited to 30 m.p.h.; in four states to 25 m.p.h.; in one each to 45, 22, and 40 m.p.h.

Many operators use governors on their buses, so that drivers cannot exceed a predetermined speed limit. In fact it is a requirement in some cities and in other states.

It is of interest to note that most passenger motor carriers are, and always have been, heartily in favor of efficient and reasonable regulation. There have been many instances in which a request for a more efficient enforcement of the state law has come from the motor carriers themselves. In general, the co-operation of the state bus associations with the regulatory bodies has been noteworthy.

A decision of the United States Supreme Court handed down in March, 1925, in the case of *Buck vs. Kuykendall*, held that the states have not the right to refuse certificates to bus companies engaged in purely interstate business. As a result of this, interstate operations have sprung up all over the country.

Interstate operation is especially the case in the New England and Middle Atlantic states. Due to the lack of regulation, competition has been severe and it has not been uncommon to see financial difficulties overtake some of the companies. A measure now pending in Congress, favored by the Motor Bus Division of the American Automobile Association, provides for federal regulation that will definitely control all such interstate operations. This bill is also favored by the larger and more responsible interstate motor carriers as was expressed at the investigation by the Interstate Commerce Commission on bus and truck operations.

Method of Taxation

What are the taxes which bus companies pay? The idea has gone abroad that there are none—that buses operate almost tax free. While tax conditions vary in different states, the average operator may be subject to the following levies:

Federal
- Income tax on personal operations.
- Income tax on corporate operations.
- Excise tax on new vehicles.

State
- Real estate tax.
- Personal property tax.
- License fee.
- Special tax on business as bus operator.
- Gasoline tax.
- Special tax for support of commission.
- Income tax (both individual and corporate).
- Corporation Franchise tax.

Local
- Real estate tax.
- Personal property tax.
- Franchise tax.
- Gasoline tax.
- Occupation tax.

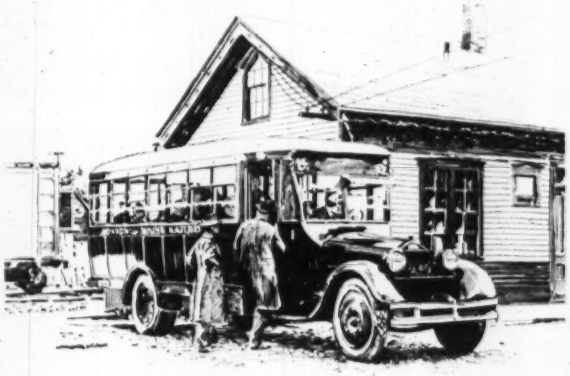
Furthermore, bus companies, in all states except California, are subject to the tax whims of legislatures that can impose a destructive levy whenever and so often "as the spirit moves." In California, by an approved amend-

ment to the constitution, state taxes have been stabilized on the same basis as for any other transportation company. From the gross receipts 4½ per cent is paid in lieu of all other taxes except the gasoline tax and local real estate taxes. This action places the California bus industry on a par with other public utilities whose rates of taxation are fixed by the state constitution.

Many Consolidations Now Taking Place

One of the most significant trends noticeable, especially in 1926 in the industry is the present tendency toward consolidation. Large operations usually result in the adoption of more businesslike methods and the injection of more transportation talent into the management.

The advantages of this merger process to the public are obvious. Operation is put on a more stable basis, improved transportation methods are adopted, equipment is kept in better condition, with a consequent increase in traffic. There is one drawback to this arrangement, however. The motor carrier who owns a few buses and operates them over one or two routes usually has a valuable personal contact with his patrons, which is lost when companies increase in size and the actual owners become more or less unknown to the patrons.



RAILROAD-OPERATED MOTOR BUS MAKING TRAIN CONNECTIONS

Association Organized for Self-Protection

A distinct desire on the part of all classes of operators to analyze and study their problems so as to improve service is increasingly evident. For this purpose 42 state associations of bus operators have been organized. Many of these are in turn members of the Motor Bus Division of the American Automobile Association, which is the national organization in the bus field.

Many of the electric railways operating buses are members of these state bus associations in their respective localities, but they are also members of a national organization, the American Electric Railway Association, which has several committees studying bus operation.

The steam railroads have their organization for the study of motor vehicle operation, the Railroad Motor Transport Conference. This body acts as a clearing house for information on the use of buses and trucks by steam railroads, and holds three meetings annually for the discussion of problems involved. It is likely that this organization will soon become a division of the American Railway Association.

What of the Future?

What is the outlook for the future of the bus? The role of a prophet is dangerous, but there are some prognostications which can be made. First of all, there is, and will continue to be, a large field for the motor carrier, using that term as denoting the company operating independently of steam electric railway organizations. Such operators will form the backbone of the common carrier field for many years to come, and the consolidating process among them will continue. They will adopt better transportation methods, and combinations of these consolidated companies will form interline agreements, so that passengers may purchase through tickets covering the routes of several carriers. Electric railways will undoubtedly find the bus of increasing usefulness to them in replacing non-paying rail routes, in opening new territory in suburban districts, and in furnishing a de luxe service in the cities without rapid transit facilities.

The steam roads will probably adopt the bus more and more for the same objects as the electric railways. The action of the Baltimore & Ohio R.R. in locating its rail head terminal outside of the congested area of New York City, and of using buses to carry passengers in and out of the congested district has provoked much comment on the part of railroad executives and may lead to further developments along similar lines by other companies.

The science and art of bus construction and operation have progressed as much in three or four years as the private automobile has in ten years, and is as near the peak of perfection as the private car. This will be a stabilizing factor, and there will be less risk of 1927 vehicles becoming obsolete than in any preceding year. There is also evident the beginning of a better understanding between motor carriers, electric railways, and the steam railroads. Each has come to have a clearer understanding of the others' views and needs, and these interests are co-operating as never before.

The bus industry has made great strides in the twelve years since the jitney first appeared on the Pacific Coast. Particularly is this true in the last two years, for keen-minded business men, men who have been successful in other lines of industry and commerce, have joined the administration ranks. Bus transportation is, however, only at the beginning of its development, and faces a great future of increased usefulness to the public. Two facts stand out for success—first, real service to the public, and second, a profit commensurate with that service.

CALIFORNIA DESIGN OF BUS: SMOKING ROOM AND BUFFET

One of four articles in this issue recording progress in the allied fields of engineering

Recent Improvements in Making Portland Cement

By FREDERICK W. KELLEY
President, North American Cement Corporation, Albany, N. Y.

Man-hour productivity increased and price kept level in face of rising costs by larger kilns, waste heat utilization, higher steam pressure and heat, larger and more efficient manufacturing units

THE manufacture of portland cement, begun in England just over 100 years ago, was carried on for some time only in countries bordering upon the English Channel and the North Sea, using as raw materials the finely divided chalks and clays of those districts, which required mixing, but little grinding.

In the United States the manufacture of portland cement did not begin until about 1872, and little progress was made until the development of crushing and grinding machinery capable of reducing economically to the extreme fineness needed, the hard lime rock found generally throughout the United States.

In the United States, wide use was first made of the rotary kiln, which by eliminating a large amount of labor then required with other kilns in foreign plants, tended for a time to equalize the cost of production. The rotary kiln is now used throughout the world to burn portland cement, and, where needed, substantially similar grinding machinery is everywhere employed.

The manufacture of portland cement is an exact, chemical-mechanical process involving the proportioning, grinding and burning of large quantities of materials under the constant control of chemists. The grinding is generally done in several stages by machines, each suited to the particular kind of material handled, and to the fineness to be reached. For convenience, the manufacture may be roughly classed in three major divisions:

(1) Preparation of the raw materials,
(2) Burning the raw material to form clinker,
(3) Grinding the clinker to finished cement.

Since raw materials used in different places include limestone of all degrees of hardness, chalk, marl, oystershells, clay, shale, and industrial by-products, there are more differences in methods and machinery for raw material preparation than in other parts of the plant, although it should be understood that probably no two cement plants are alike in all their details. Each plant must with the materials available achieve in the best way the results required by the Standard Specifications.

The major problems involved in the design and operation of a cement plant after securing a site with suitable raw materials, located where there are adequate transportation facilities and markets, are:

Proper crushing, grinding, and burning machinery, suitably housed.

Mechanical handling and transportation of all materials involved in the several operations, to eliminate hand work.

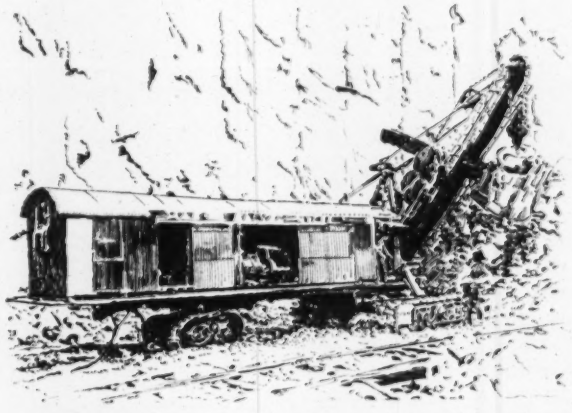
Provision for adequate power and its distribution.

Means for making immediate repairs and insuring continuity of operation.

Convenient and adequate storage for raw material, clinker, fuel, gypsum, finished cement, and operating supplies of many kinds.

Adequate means for chemical and physical control of all materials, to assure proper proportioning, blending and grinding, and proper burning.

The weight of raw materials and fuel to be handled in the average cement plant approximates twice the weight of the finished product. The portland cement industry is one of the three industries in the United States using the most power per dollar value of product.



ELECTRIC SHOVEL DIGGING IN LIME ROCK

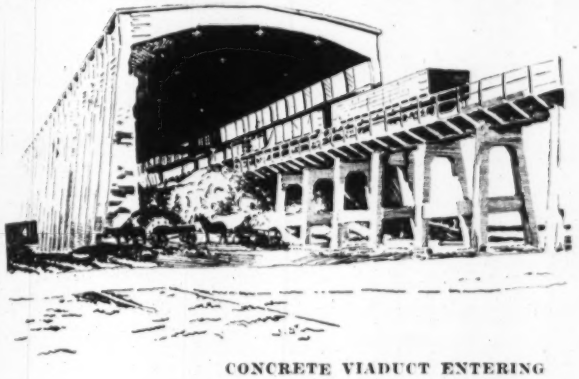
Kind of Machinery Used

The machinery in a typical cement plant in the United States using hard rock and clay or shale for raw materials, includes drilling apparatus, large power shovels and cars as employed in other large scale quarry operations, to secure material and deliver it to primary crushers, followed by secondary crushers; proportioning and blending apparatus, raw material grinding machines, rotary kilns for burning, grinding machines for fuel and for clinker, conveying machinery of many kinds, weighing and packing devices, motors, power production and transmission equipment, and machine shop for repairs.

The reduction of the raw materials to a fineness such that 80 to 90 per cent will pass through a sieve having

200 openings to the lineal inch, is sometimes wholly or partially accomplished by a variety of high speed machines which both pound and rub the material, but probably the most generally used machinery for this purpose is the slow speed ball and tube mill types.

A tube mill is a horizontal steel cylinder, generally 6 to 8 ft. in diameter and 20 to 30 ft. long, supported to revolve about its axis. The cylinder is lined with



CONCRETE VIADUCT ENTERING LIME ROCK STOCK HOUSE

wearing plates and is partly filled with steel or hard iron, spherical or cylindrical grinding elements about ½ in. to 1½ in. diameter. The speed is generally from 20 to 30 r.p.m. The material to be ground is introduced at one end and passes out at the other, being reduced in size by action of the shifting charge in the revolving cylinder.

A ball mill is a steel cylinder of about the same diameter as a tube mill, but of somewhat less than half the length, while the grinding elements are steel balls from 3 to 5 in. in diameter. The ball mill does the coarse grinding and furnishes a product of size suitable for the tube mill which it precedes. Sometimes the ball and tube mill are combined in one longer cylinder with compartments so arranged as to separate the grinding elements, but to permit the passage of the material to be ground. Mechanically operated screens and air separators are sometimes used.

The wet process of manufacture differs from the dry process in that the raw materials are mixed and ground with water to form a "slurry," and are introduced into the kiln in this condition, instead of as a powder ground from dried materials as with the dry process.

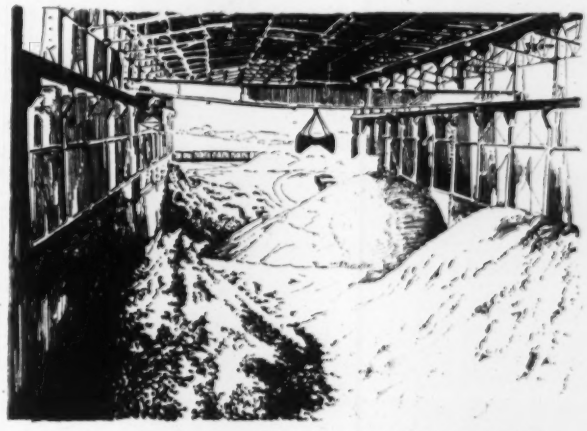
The wet process was originally used with soft raw material having a high moisture content. It was later adapted to low moisture raw materials, with a view to securing an easier or better blending for the kiln feed. It uses more fuel per barrel of clinker burned in the kiln, but avoids the use of fuel in drying the raw materials. The dry process is widely used with hard raw materials having low moisture content. Less fuel per barrel is used in burning, but some fuel is generally required for drying the material before fine grinding. There are claims made regarding the relative power consumption, and relative amount of dust involved in the use of each of these processes. These must be considered and decided by the plant designer who in each case must determine which process, with the particular raw materials at hand, will give the highest quality of product, most efficiently.

The rotary kiln, in which portland cement is now almost universally burned, is a steel cylinder supported at a slight angle from the horizontal in such a manner that it can be rotated about its axis at a very slow speed. The raw material, fed into the upper end of the kiln, by the action of gravity combined with rotation moves slowly toward the lower or discharge end, meeting the hot gases of combustion from the flame of a mixture of powdered coal and air which is constantly blown through a hood covering all but a small aperture in the lower end of the kiln, through which the hot clinker is discharged. In some places oil or gas is used instead of pulverized coal. A special department for drying and grinding coal for kilns is provided in plants using coal, which in 1923 were reported as 78.7 per cent of the total in the United States.

Both kiln and hood are lined with fire-brick, to resist the high temperatures which reach 2,800 deg. F. in the burning zone near the lower end, where the change from the mechanically mixed raw materials to the new chemical combination known as portland cement clinker takes place.

The upper end of the kiln is connected to a stack to care for the products of combustion. Waste heat boilers when used are placed between the kiln and the stack. Gases entering the waste heat boiler at from 1,000 deg. to 1,600 deg. F. depending upon conditions, leave the boiler and economizer at about 400 deg. F.

The clinker issuing from the kiln in a red-hot con-



STOCK HOUSE STORAGE WITH CRANE CONTROL

dition contains much heat which is sometimes used to pre-heat the air entering the kiln to support combustion of the fuel. A common type of clinker cooler is a separate rotating steel cylinder placed at a lower level than the kiln, either under the kiln or in line with it. The high temperature and the abrasive character of the clinker, which is hard enough to scratch glass, make it difficult to handle.

The machinery used in grinding clinker to finished cement, is in general quite similar to that described for the last two stages in the reduction of the raw materials.

In the final stage of grinding a small quantity of gypsum is introduced with the clinker to insure a setting time which will be convenient for making concrete. At least 78 per cent of the finished cement must be fine enough to pass through a sieve having 40,000 meshes per square inch. Such a sieve has a finer weave than most silks, and will hold water. The cement after sampling and testing to insure full compliance with the

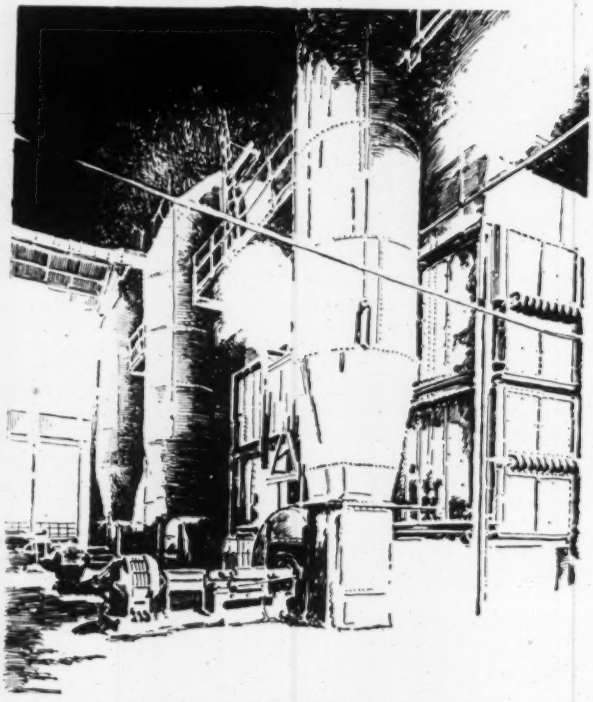
Standard Specifications, is held in bulk in large storage bins until placed in weighed packages for shipment.

The United States Bureau of Mines reported 138 cement plants in the United States in 1925, located in 29 states, thus bringing the product near to most important consuming markets. The capital investment in plant is high and the rate of capital turnover about once in two years. Manufacturers have had to rely upon a large volume of business for profits on their product which sells for a lower price per pound than any other highly manufactured article.

Increasing Productivity

The above brief outline of the manufacture of portland cement will assist in a better understanding of some of the following improvements which have recently been made by the industry in this country.

The greatest problem of our cement industry during the last few years has been to keep cement a relatively cheap commodity in the face of the tremendous increase in most of the essential elements which make up its cost, and at the same time preserve and improve the quality of the product. The United States Geological Survey for 1923 in comparing prices of building materials for December, 1923, with 1913 prices says: "But a few materials of minor importance show a smaller percentage of increase than cement." An increase in the strength requirements of the standard specifications, adopted in the summer of 1926, reflects the general improvement that has been made in quality of product.



PART OF BOILER INSTALLATION IN CEMENT PLANT

A recent statement of the United States Bureau of Labor Statistics, showing an increase of 57.8 per cent in man-hour productivity in our cement industry in the period from 1914 to 1925, was said to be the greatest production increase of the four industries analyzed by the department.

Some of this improvement in man-hour productivity has been due to the increased use of machinery by the industry. The investment per worker in the cement industry is estimated to be about $13,000, and is considerably above the average investment, which in the 1919 census was $4,888 per worker in manufactures in the United States.

Some of the improvement in man-hour productivity is unquestionably due to the better conditions of our industry which have grown out of the splendid Accident Prevention Work of the Portland Cement Association. In 1925 there were 47 cement plants which made a better safety record than the best cement plant in 1919.

Detailed Improvements

As a means of increasing output and improving fuel efficiency the old standard 6 x 60-ft. rotary kilns have been generally discarded, and those of greater length and diameter employed. Diameters of 10 to 12 ft. and lengths of 175 to 250 ft. are not uncommon, while lengths up to 330 ft. on wet material are coming into use. The most suitable diameter and length in each case depends among other factors upon the total capacity of plant, character of material, and the use of waste heat boilers. Special insulation has been used between the kiln shell and the brick lining to prevent radiation losses, except in the hottest zone where radiation seems to be necessary in order to preserve the materials out of which the kiln and lining are made.

More general efforts have been made to utilize the heat in the finished clinker as it leaves the kiln. In some cases refinements in the means for accomplishing this have, because of the temperatures involved, led to operating delays which more than offset the fuel economy. The most recent clinker coolers form an extension of the lower end of the kiln and revolve with it.

The heat in the stack gases from rotary kilns is being more fully utilized than heretofore by means of waste heat boilers and economizers. These are more generally used, and the newer installations include boilers, settings and auxiliaries designed for this special purpose, with a view to overcoming some of the difficulties found in the earlier installations with boilers designed for power plant conditions. There were 57 waste heat installations in use or under contract in 1926, against 4 in 1915. Waste heat boilers are now designed for a much higher velocity of gases than formerly, since it has been found that this increases the rate of heat transfer through the boiler tubes, and the gas passages have been made considerably longer, since this tends to reduce the exit gas temperature. These changes have caused a considerably greater resistance in the boiler and have put more work on the exhaust fan, which is installed after the boiler and economizer. These exhaust fans have been improved in design and material.

The tendency has been toward a higher steam pressure, more superheat and the utilization of the steam in prime movers with better steam efficiency than heretofore used in the industry. Pressures of 225 lb. are common in new installations, and superheat of 100 deg.

There has been a tendency to substitute a few large-capacity units for a greater number of smaller units in

crushing and grinding machinery, and to adopt machinery requiring the least attention and repairs, even at the expense of slightly more power.

Power transmission belts and line shafts are disappearing. Individual direct-connected induction motor drives sometimes involving speed reduction gear of considerable capacity are common practice. Synchronous and super-synchronous motors are well adapted to many situations in cement plants. Units up to 600 kw. are used.

Conveying and elevating machinery has tended to become more simplified and more rugged. Pneumatic conveying devices have been successfully used on fine materials, especially pulverized coal and cement. The overhead traveling crane placed in a suitable storage building of considerable length handles large quantities of heavy materials. Gypsum, stone, clinker and coal can be stored in a single building properly placed and one crane delivers them to points of use.

Steam or electric shovels of large capacity and improved ruggedness, frequently with caterpillar mounting, perform the quarry work as in other industries.

Storehouses for finished cement have increased greatly in capacity. Notwithstanding the tendency toward winter building construction because of economies thereby possible, the seasonal character of the cement industry makes large storage capacity inevitable, as well as means for handling cement efficiently in and out of storage. Concrete silos adapted from designs largely used for grain elevators are used in new installations.

Much study has been given to devices for controlling the many kinds of dust incident to the manufacture of cement, but because of the individual pecularities found the problem is a difficult one.

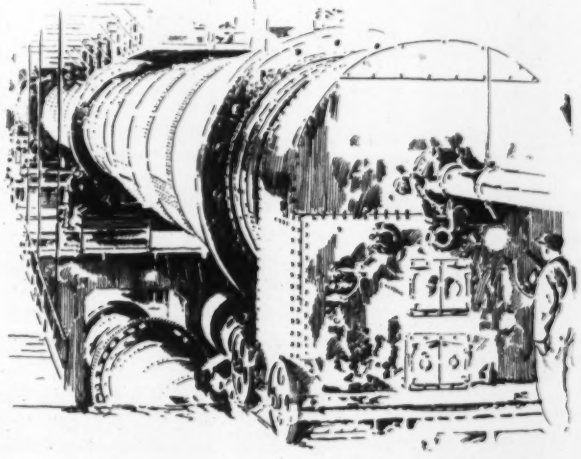
The general character of construction in our cement plants has been rapidly improved and the fire hazard thus greatly reduced, insuring continuity of operation.

Automatic systems for weighing and proportioning with improved methods of mixing and blending have helped in the chemical control of the constant stream of materials passing through the average cement plant, assuring greater uniformity in product and in results.

Better Concrete

The view that cement is but one of the elements which go into the manufacture of concrete and that the quality of the concrete to be obtained can be varied within wide limits by differences in proportioning and mixing these elements and in placing the concrete is largely confirmed by research work.

Unlike other products which come to the user in finished form and hence require large variety, cement by its nature is more convenient for the average user when of a proper standard quality. The user can then more readily predict the results in concrete produced by known methods, securing with one cement a great variety of quality and strength in concrete.



ROTARY KILN USED IN MAKING CEMENT

Such a standard product can be most readily and cheaply provided at the many centers of use throughout the country, can be handled with a minimum investment by the retailer, and can provide for all the needs of the builder except possibly in certain extreme cases.

The extensive research into the factors affecting the use of cement in concrete which has been carried on for about twelve years in the laboratory of the Portland Cement Association, and which has received world-wide recognition, has been supplemented during the last two years by research on the constitution of portland cement carried on by the association, in co-operation with the United States Bureau of Standards, in Washington. These researches are giving an increasing fund of accurate information, upon which improvements in manufacture, in use, and in specifications for portland cement can be safely based, thus insuring better cement, better concrete, and a sound development of the industry.

Foreign Competition

Notwithstanding the improvements, and efficiency in our industry as heretofore noted, the lower standards of living and the depreciated currencies in parts of Europe have created conditions which make it impossible for the American cement manufacturer to meet the price competition of foreign cements at certain points along our sea-coast. Present conditions provide ocean freight rates which are less for a 3,000-mile movement than are freight rates for a few hundred miles. There is no likelihood of an early material change in the factors causing this situation.

In the European country from which comes most of the cement imported free of duty into the United States, a cement plant man-hour costs about one-fifth that of an American man-hour in our cement plants. This lower wage rate enters into the direct labor cost of cement, and also into the cost of all fuel and supplies and into their transportation, as well as into the cost of the machinery and buildings composing the plant, and hence into the interest and depreciation charges based thereon. So that, with similar machinery and processes in both countries, there is a big difference in costs, over which the American manufacturer has no control.

Our cement industry is without tariff protection on shipments of cement from countries which admit cement free of duty, in accordance with reciprocal tariff ideas. But there can be no reciprocal trade, in such a commodity, under existing conditions. Unless we are ready to accept the standard of living of the European countries from which cement is imported free of duty, a tariff protective of our standards is warranted, and is in fact immediately required, if the cement industry in this country is to be able to continue its heretofore excellent record in meeting and surmounting the difficulties of its environments.

One of four articles in this issue recording progress in the allied fields of engineering

How the Steam Power Plant Is Keeping Up-to-Date

By C. H. BERRY
Associate Editor of "Power," New York City

Steam the dominant medium for power generation—Major steam plant losses and methods of attacking them—Industrial plant economy secured by combining power and heating requirements

IN A BRIEF review it is impossible to deal exhaustively with a subject so broad. The effort will therefore be confined to the discussion of a few of the newer features of steam power plant design that have recently been the subject of considerable publicity. An effort will be made to strip them of the aura of magic that surrounds them in the lay mind and to point out their merits from an engineering point of view, and their bearing in the reduction of losses.

A word as to units of large size. The past year has seen the record thrice broken in the turbine field. An 80,000-kw. unit is running in Brooklyn, a 160,000-kw. unit is being built for service in New York, and an order has been placed for a 208,000-kw. unit for the Chicago district, the latter for a new plant designed to house five such units. Boilers also are growing. The largest thus far is a unit of 41,000 sq.ft. that went into service during the year 1926. This would rate as 4,100 boiler-horsepower according to the old scheme of rating that the mechanical engineer is trying to forget. Large size brings problems in construction and handling, but none in the field of steam generation and utilization. To the plant owner the large unit brings increased capacity per unit of ground area and somewhat better economy in plant cost and operating expense.

Steam Plant Losses

In considering the function of various devices in the plant for reducing losses, it is well to regard the plant as a whole, from the outside looking in, as it were. From this point of view, there are only six paths by which energy is lost:

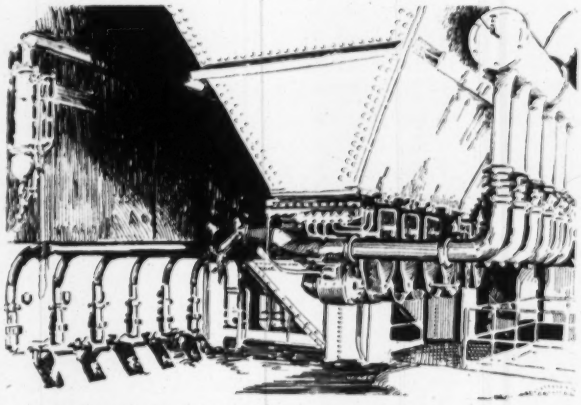
Boiler room losses:
- Through the chimney.
- Through the ash pit.
- Through the boiler blow-off line.

Engine or turbine room losses:
- Through the condenser.

Plant losses:
- Through the "radiation" of heat.
- Through leaks.

The chimney loss lies in the discharge of hot gas that might have yielded heat for useful ends, and in the passage of excess air through the furnace in excess of that required for good combustion. This air enters cold and is discharged hot. In addition, there is the loss due to the discharge of unburned combustible gaseous constituents. Their presence is an evidence of bad combustion conditions, and the remedy lies in the control of the fires.

The ash-pit loss is principally a loss of fuel that should have been burned. In a hand-fired plant, the



TYPICAL BATTERY OF PULVERIZED COAL FEEDERS AND BURNERS

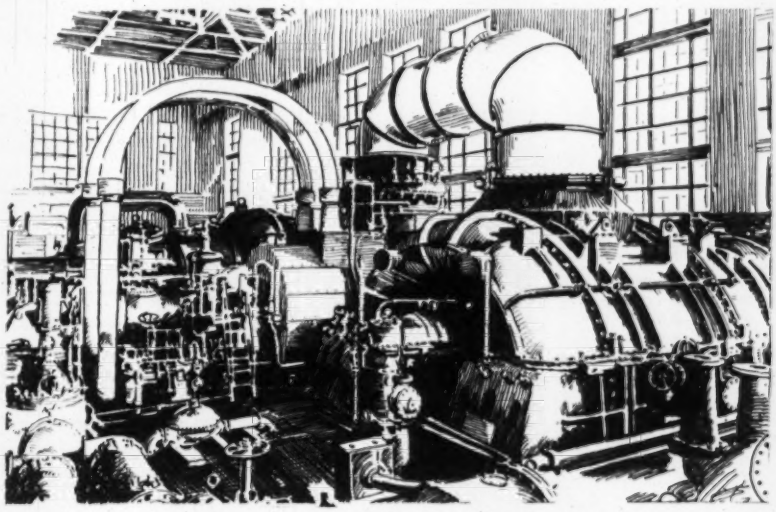
furnace refuse is frequently one-third or even one-half combustible material—coke, most of which could have been burned with proper attention. The fact that the refuse is discharged hot also represents a loss, but ordinarily this is small, and no serious efforts have been made to overcome the obvious difficulties of recovering this heat.

The loss through the boiler blow-off line is direct and sometimes large. Water is heated to the boiling point and discharged to the sewer. There are two remedies in common use. One is to reduce the quantity of water blown down. In some plants this is reduced to zero, that is, the boilers are never blown down. With distilled feed water this practice seems proper, but otherwise it is impossible. But in any event excessive blowing down should be avoided. The other remedy is to provide a heat exchanger wherein the blow-down water heats cold water en route to the boiler.

Even in the best modern plants, the loss through the condenser usually exceeds half the heat supplied in the fuel. Carried out by water warmed only ten or fifteen degrees, its recovery seems hopeless. The magnitude of this loss attracts the uninformed inventor, who has given us numerous perpetual motion machines obscured behind a mass of specious thermodynamic reasoning that looks formidable enough to prove anything. As a mat-

ter of fact, so far as present knowledge and experience guide us, we must conclude that the reduction of the condenser loss to anywhere near zero is not only impracticable but is theoretically inconceivable. Small reductions are possible, but complete elimination is out of the question. The reasoning leading to this conclusion is a long story, involving the whole of thermodynamic theory. The simple statement must suffice here.

The loss of heat through "radiation" is conspicuous in many plants in which heat insulation has been neglected. Insulation pays. Lots of it.



80,000-KW. COMPOUND TURBINE UNIT, THE LARGEST UNIT NOW IN OPERATION

Losses by leakage of steam and hot water are ordinarily inexcusable. The operating engineer is responsible, and the owner should insist that he keep his plant tight, at the same time co-operating with him by furnishing adequate tools and supplies.

Another type of loss in the power plant is financial, that is, the cost of maintaining equipment in first-class operating condition. This varies widely with conditions and is often a matter of serious concern. The pay roll for the plant operating crew is also subject to some variation.

How the Losses Are Attacked

In general, the method of attacking any loss is twofold—reduction at the source by improvement of the process and reclamation for heating combustion air and boiler feed water. Since both air and water are initially at low temperature, they can utilize heat from relatively low temperature sources and hence furnish a ready means for the recovery of waste.

There are seven features of power plant equipment and method that have been lately in the limelight:

Higher steam pressures and temperatures.
Steam extraction for heating feed water.
Steam reheating.
Pulverized coal.
Economizers.
Air preheaters.
Water- and air-cooled furnace walls.

Each of these is a direct attack on one or more of the plant losses, and a discussion of the manner and the extent of the effectiveness of these methods may be of value.

Higher Steam Pressures and Temperatures—Increasing the pressure and temperature range through which steam expands results in the development of more mechanical work per pound of steam, and thus, for a given quantity of heat supplied in the boiler room, it reduces the heat loss through the condenser.

The initial temperature of steam seems to be definitely limited for the present to a maximum of about 750 deg. F., because no construction materials are available that will withstand higher temperatures without serious impairment of physical properties. There are many plants operating with steam at temperatures ranging from 700 to 750 deg. F. In this respect, the front rank of actual practice is numerically strong.

With respect to high pressure the leadership is confined to a few pioneers. There are two central-station plants with high-pressure boiler and turbine units, one operating at 1,200 and one at 1,300 lb. per sq.in. One large industrial plant is installing an 800-lb. unit, and two or three others are projected. In Europe there are a few plants using 1,500-lb. steam and there is said to be one boiler generating steam at about 3,200 lb.

The limit to high pressure is largely in the cost of equipment. The high-pressure boilers in this country have seamless forged steel drums with walls four inches thick. Turbine casings, piping, and valves must of course be very heavy. All this costs money. But there seem to be no new operating difficulties. Where high load factor makes small increments of economy yield their full annual return, increasing use of high pressures may be expected.

Steam Extraction for Heating Feed Water—In a condensing plant the bulk of the feed water originates in the main condenser, as cold water. This water could be fully heated by the hot chimney gas, but this leaves the combustion air still to be heated, and, since the heating of this air provides a simple means for reducing the chimney gas loss to a low figure, it is usually considered preferable to heat the cold water with steam extracted or "bled" from the turbine. The principle is old. It was applied years ago to quadruple expansion mine hoists, but such engines are scarce, and the general application of this method has had to wait for the steam turbine, which lends itself readily to such an arrangement.

Since the water is to be heated through a range of 200 or 300 deg., it is expedient to use three or four heaters drawing steam from successively higher pressure stages of the turbine, so that each portion of steam develops the maximum quota of mechanical work by expansion in the turbine.

Operation on this regenerative cycle reduces the loss through the condenser by 15 or 20 per cent because about that fraction of the steam is withdrawn and never reaches the condenser. Each portion of steam extracted fails to produce the work it would have developed in the turbine stages following its exit, so that there is a small offsetting loss of work, but the net result is a material saving in the fuel bill. The equipment for effecting this

saving is relatively inexpensive and this type of plant layout is now widely used.

Some designers use extracted steam for heating the combustion air, and the hot chimney gas for heating water, but the prevailing opinion seems not to favor this plan.

Steam Reheating—As steam expands, it tends to condense progressively. Initial superheat is presently lost, and at some point in the turbine moisture appears and is carried in suspension by the steam. Moisture-laden steam dissipates energy through friction more rapidly than dry steam, and produces a serious wear of turbine buckets, which appear as though sand-blasted. This effect is more pronounced the higher the initial pressure, and at pressures above 400 or 500 lb. becomes so serious that it is important to reheat the steam, evaporating the entrained moisture.

Reheating is accomplished by withdrawing the entire stream of steam from the turbine and carrying it back to the boiler room to a resuperheater whence it returns to the turbine, or to use a reheater located adjacent to the turbine. This process is expensive in equipment and piping, but under favorable circumstances pays an adequate return in improved turbine economy and reduced wear. Reheating is an accepted accompaniment of high initial steam pressure.

GOOD EXAMPLE OF MODERN STOKER PRACTICE IN AN INDUSTRIAL PLANT BOILER ROOM

Pulverized Coal—The principal advantage of pulverized coal to the boiler room seems to be in the reduction of operating costs, through the reduction of labor and through the ability to use coals of a wider range of quality, so that better advantage can be taken of adverse market conditions. Coal having an ash of low fusing temperature may give rise to serious clinker formation on a stoker, and yet be handled with comparative ease in pulverized form. However, it is true for pulverized coal as for stokers that the better the coal the better the results.

When a pulverized coal system is compared with mediocre hand-firing practice, there is a distinct increment of efficiency in its favor, but the same might be said of the competing stoker installation. For comparable installations it appears that pulverized coal and stokers yield about the same operating efficiency. It is impossible to conclude from the meager experience thus far available that either is definitely superior to the other in efficiency obtainable. The differences come in the ease with which satisfactory performance is obtainable.

It is true that the pulverized coal furnace has lower banking losses than the stoker or hand-fired furnace. Also, with pulverized coal control is easy and response prompt, so that it may be possible in day by day operation to approach closer to test conditions than can ordinarily be done with a stoker in the hands of the usual fireman. Automatic control of either stoker or pulverized coal furnace, however, somewhat mitigates this discrepancy.

A few years ago, when pulverized coal was first vigorously introduced to boiler furnace practice, it was rather freely assumed that the ash pit loss would be much less than with stokers, since it seems obvious that the tiny particles of suspended ash must be burned completely free of combustible material before they leave the furnace. Now that several plants have been in operation for some time, there is reason for questioning this, although final conclusions as yet are impossible, due to the difficulty of securing representative samples.

A serious problem in connection with the use of pulverized coal in any plant is the disposal of the ash. Without special preventive measures, a large proportion of the total ash in the coal will be blown up the chimney. In cities and in many rural localities this would be open to strenuous objection, if not to police interference. Fortunately there are now available effective means for intercepting this dust, albeit at some expense; and unfortunately, catching this dust, while it may avert a nuisance, presents a serious problem of disposition. This ash is a fine dry powder. It cannot be carted away in any open-top vehicle, for even a light breeze will blow the container empty. The ash is not a good fill, unless it can be kept wet until a suitable top dressing is applied. Many stoker plants sell their ash pit refuse. Thus far no purchasers have appeared for pulverized ash.

Economizers — The economizer is an old device, although for many years it was a structure of cast-iron tubes unsuited for high-pressure service. During recent years steel tube economizers have been developed. They are subject to corrosion difficulties and are costly. Since the water can be heated by extracted steam, and since the heating of combustion air affords a ready means for reducing the chimney gas loss, there appears to be a growing tendency away from the use of economizers, although they are far from obsolete. Where heated air cannot be used, the water heating economizer is usually preferable to extracted steam heaters.

Air Preheaters—The chimney gas loss can be reduced almost to zero by preheating the cold air that enters the plant to support combustion.

The heat exchanger is a simple structure of tubes or plates, with welded joints, and no serious operating difficulties are entailed.

In addition to the heat recovered, there is a further benefit in improved combustion conditions, and it now seems that air heated to 500 deg. F. can be used with either pulverized coal or stokers with wholly beneficial results. As the art develops even higher temperatures may be used successfully.

With gas leaving the boiler at, say, 600 deg. F., air can be heated to 500 deg. F., the gas finally issuing below 200 deg. Crediting one per cent for each 35 to 40 degrees reduction in gas temperature, air preheating may decrease the coal bill by more than ten per cent.

Water-Cooled Furnace Walls—The water-cooled furnace wall is widely used in an effort to reduce maintenance costs through the displacement of refractories subject to severe service conditions due to increasing rates of heat liberation per cubic foot of furnace volume.

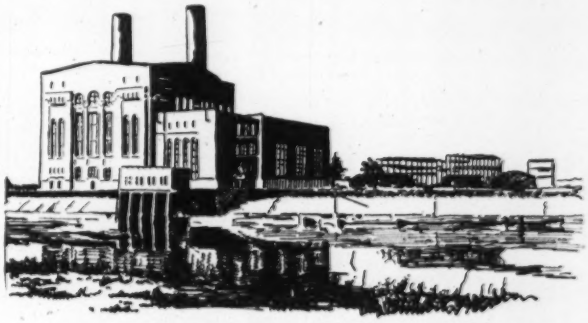
The life of a refractory wall can be considerably increased through air cooling. The air required to support combustion of the fuel is led through ducts in the furnace walls. This cools the brick and heats the air, so that wall maintenance is reduced. However, it has not proven practicable to heat the air to a high temperature, and the cooling of the wall is not as effective as might be wished. Water cooling is better.

The water-cooled furnace wall is by no means new. Internal furnace boilers, of the Lancashire, Scotch marine, locomotive and Continental types have been used for years. Recent progress has been in the development of designs adapted to the water-tube boiler. These build a wall entirely or partly of water tubes connected to the boiler, or comprising a separate boiler. These tubes may be exposed directly to the furnace gas or protected by a metal or refractory covering shrunk or bolted to the tube. Naturally these tubes receiving direct radiation from the fire, absorb heat at high rates, and accordingly they displace a disproportionately large amount of ordinary boiler surface, so that the development of the water-cooled wall has led to radical modifications in the design of the boiler.

Thus far there are few fully water-cooled furnaces in service, so that results cannot safely be predicted. Some engineers fear that ignition will be difficult and combustion incomplete. Others fear that the exposed tubes will be in danger of failure from overheating. For the ignition and combustion difficulties preheated air may prove to be a complete solution. For the tube failures, should they develop, there are remedies in the rearrangement of the water circulating system of the boiler.

The Industrial Plant

Some industrial power plants do not differ from central station power plants, and for these the problems and possibilities are identical. Many industrial plants, on the other hand, have a situation all their own in that they are called upon to supply not only power but also steam for building heating or for heating in manufacturing processes. In such cases there is a more or less complex problem in balancing the demands, with possibilities of savings that are often astonishing to the uninitiated. Increasing use of turbines exhausting at high back pressure, and of extraction turbines, characterizes this field, and ingenious governing systems are used whereby pressures can be controlled within narrow limits. Plant owners having a combined power and heat demand will do well to study their situation with care, or to secure the services of a competent consulting engineer to do it for them. The rewards are often very considerable.



THE MODERN CENTRAL STATION ARCHITECT IS DEVELOPING HIS ART EFFECTIVELY

Thermo-Chemical Treatment of Coal

There has recently been much talk of preparing lubricating oil, fuel oil, gasoline, and the like, by various treatments of coal, with coke as a byproduct. While it is true that several such processes have been demonstrated on a laboratory or sub-commercial scale, and that one or two coal treating plants are in successful commercial service, it is nevertheless safe to say that for the present the power plant owner need not concern himself too seriously with these possibilities. Present markets for the liquid products in this country can hardly support the expense of preparing them from coal. As the petroleum resources of the United States approach exhaustion, as predicted for the not too remote future, the inevitable rise in prices will open the way for these methods of coal processing which are already coming into prominence in Europe.

Conclusion

The art of power plant design is alive and active, and accordingly this article has had to speak of opinion and preference and tendency. There is no one best plant design. Each undertaking involves its own set of circumstances, and a perfect solution for one plant might be a very indifferent job elsewhere. The growing demand for high economy in total power cost, including the cost of money as well as that of fuel and labor, can be met only by the application of high talent. The mechanical engineer is measuring up to the need, and his success thus far augurs well for his ability to carry on.

Through the intelligent application of sound engineering the cost of power or of power and heat can be materially reduced. This is done through the use of equipment whose effectiveness has been demonstrated in actual service, and involves no element of guesswork or magic. Marked steps have already been taken to this end, and we may confidently look forward to further accomplishments and to a wider use of the benefits already achieved as older plants are displaced or remodeled in the course of normal industrial progress.

News of the Week

Current Events in the Civil Engineering and Contracting Fields

Work on Elevated Highway at New York to Start Soon

Speaking before the New York Section of the American Society of Civil Engineers on Jan. 5, C. M. Pinckney, chief engineer, office of the president, Borough of Manhattan, stated that the test borings had been completed for the foundations of the proposed elevated highway along the west side of Manhattan Island from Canal St. to 77nd St., that the location work would be completed in February, and that it was hoped to be able to ask for bids by mid-summer. The present plans call for a single deck for six lanes of traffic with provision in the footings and columns for the construction of a second deck when required.

Two New Members Added to Firm of Metcalf & Eddy

The firm of Metcalf & Eddy, consulting engineers, Boston, has been enlarged by the admission of Arthur L. Shaw and E. Sherman Chase as partners, both of whom have been with Metcalf & Eddy for a number of years. Mr. Shaw joined the staff soon after his return from Germany, where he was in the Army of Occupation as captain of the 301st Engineers. Mr. Chase had been assistant engineer of the New York State Department of Health for several years before joining the firm. The firm will move into the new Statler Building, as soon as completed, probably about Feb. 1.

No Decision Yet on Newark Bay Bridge Closing Plea

A report to the effect that the War Department had decided not to authorize the closing of the draw spans of the bridges across the Passaic and Hackensack Rivers and Newark Bay for two hours night and morning, in order to facilitate the movement of commuter traffic to and from New York City, recently published in New York and New Jersey papers was made without foundation. The Chief of Engineers had not yet reached a decision in the matter and no ruling has been made by the War Department.

Work Begun on Railway in Maine

Work was begun on Dec. 27 on the Quebec Extension R.R. in Maine. The new line will extend from Washburn, Maine, to a connection with the Quebec Central at Lake Frontier in Quebec, a distance of 111 miles. The certificate of the Interstate Commerce Commission authorizing construction of the railroad would have expired on Dec. 31 if work had not been started. The estimated cost of the line is $5,000,000.

Toll Bridge Interests Plan United Front

Movement Is Initiated Against Regulation—State Highway Officials Reply

A movement to unite all toll bridge interests for mutual protection against legislation and regulation has been initiated by E. T. Watson, of the New Orleans Pontchartrain Bridge Co., who has called a meeting of these interests at St. Louis on Jan. 17. The call for the meeting, issued Dec. 23, says:

"After careful consideration, Mr. Klatt of the American Toll Bridge Company, the officers of our company as well as its directors—who are all investment bankers—feel that it is an opportune time for all toll bridge companies to unite in one national association similar to that which is now in existence for public utilities, railroads, banking and investment banking.

"There are, at the present time, at least 150 toll bridges in operation in the United States, a few are in course of construction and many more are contemplated. By forming a national association to act as a clearing house for our mutual problems, for exchange of ideas, for the securing of statistical data, construction problems, toll collection methods, and to look after all leg-

(Continued on p. 94)

Engineering Fifty Years Ago

From *Engineering News*
Jan. 13, 1877

THE canal question is likely to come prominently before the New York Legislature. The business of the main lines has shown a great falling off, and although the tolls have been low, a still further reduction is asked for. The Buffalo Board of Trade has asked that only sufficient tolls be taken to provide for the repairs, thus cutting off the State from any prospect of revenue. This request is an admission that the canals have failed to do what was expected of them. . . .

If the canals cannot be made to pay their own expenses, it is suggested that they should be sold. No business man would retain property on which he was experiencing a continual loss, and if careful and economical management by the State cannot make them pay, they ought to be disposed of to parties who might believe they could make them do so, if such persons can be found.

Report Made on Steam Operation of Moffat Tunnel

J. G. Sullivan, former chief engineer of the Canadian Pacific Ry., under whose direction the Connaught tunnel in the Canadian Rockies was built, has made a report to the Denver & Salt Lake R.R. on the feasibility of steam operation through the Moffat tunnel and on the type of ventilation to be used. When construction of the tunnel was started it was generally supposed that electric traction would be used on account of the great length of the tunnel.

Work Started on New Hydro Plant

Work has been started on a new hydro-electric plant on the north fork of the Rogue River in Oregon by the California-Oregon Power Co., according to an announcement by H. M. Byllesby & Co. The new plant will have an initial capacity of 22,000 hp. and an ultimate capacity of 66,000 hp. It will be known as Prospect No. 2. There will be a diversion dam two miles above the power plant, 6,600 ft. of open canal, 3,100 ft. of wood pipe and 980 ft. of steel penstock. The plant will operate at a head of approximately 600 ft. The initial installation is expected to be completed by Oct. 1, 1927, at an estimated cost of $3,250,000.

Alabama Power Co. to Reconstruct Upper Tallassee Plant

Early this spring the Alabama Power Co. will begin the reconstruction of the Upper Tallassee hydro-electric power plant on the Tallapoosa River near Montgomery, Ala. The present plant develops a head of 36 ft. and has an installation of only 8,500 hp. The new plant will develop a head of 57 ft. and the initial installation will be 2 units of 25,000 hp. each with provision for a third unit of similar capacity.

The construction work will be carried on by the Dixie Construction Company, the construction unit of the Alabama Power Co., which will build its camp between the Upper Tallassee dam site and the Lower Tallassee dam site so that the redevelopment of the lower site can be undertaken when the construction work at the upper site is finished.

Hudson Bay Railway Progress

A start has been made on the work of laying rails on the uncompleted 92 miles of the Hudson Bay Ry. The approaches to the Kettle Rapids bridge, on the north side, have been completed, and it is planned to lay the rails to the Limestone River this winter if weather permits, so that footings for the Limestone bridge can be put in before spring.

State Gasoline Tax Upheld by U. S. Supreme Court

In a series of decisions without written opinions, the U. S. Supreme Court on Jan. 10 dismissed four cases which sought to invalidate state laws requiring registration fees for motor vehicles and imposing gasoline taxes. The effect is to sustain state laws with these requirements. On the authority of prior decisions involving similar questions, the high court dismissed the cases on the ground of lack of jurisdiction.

Two cases from Washington State, W. S. Cunningham and others, and Walter Nelson and others, against W. G. Potts, state treasurer, had been brought in the U. S. District Court, seeking to have the gasoline tax and the registration law nullified on the ground they were violative of the federal constitution as interfering with interstate commerce and violative of the Federal-Aid Act. It was claimed the Federal-Aid Act provided that roads improved with federal funds should be free from tolls of every kind, and that the registration fee and the gasoline sales tax were, in effect, tolls. The district court had dismissed these bills, and is upheld by the Supreme Court.

In the cases of L. Anthony and others and I. S. Martine and others against Sam A. Kozer, secretary of state of Oregon, it was claimed that the gasoline tax was illegal and violative of the Federal-Aid Act. The return of more than $6,000,000 collected under this tax was sought in this suit. The U. S. District Court for Oregon had dismissed these suits, and the Supreme Court upholds this action.

In all four cases, the lower courts had held that there was no cause for action, that the registration requirement was a reasonable state matter and that the gasoline tax was a tax on sale and not upon use.

State Commissions Cannot Control Interstate Utility Rates

A state public utility commission cannot regulate electric rates where the current is transmitted from one state to another, and the only method of obtaining control over a contract of an interstate character is through Congress, the United States Supreme Court held Jan. 3 in the appeal of the Public Utilities Commission of Rhode Island and the Narragansett Electric Lighting Co. from a decision of the Rhode Island Supreme Court in favor of the Attleboro Steam & Electric Co. Justice Sanford delivered the opinion for the majority, upholding the state court, while Justice Brandeis dissented.

In 1917 the Attleboro company, supplying electricity in Attleboro, Mass., and vicinity, contracted with the Narragansett company, operating a plant at Providence, R. I., to supply it with current at the state line and thereafter dismantled its steam plant at Attleboro. After having attempted to have this 20-year contract revised by agreement with the Attleboro company, the Narragansett company filed a new schedule with the Rhode Island Public Utilities Commission, which held a hearing and allowed the new schedule for this contract on the ground the rate was too low and causing a loss which was unfair to the Rhode Island customers of the Narragansett company. The Attleboro company appealed to the Rhode Island Supreme Court on the ground the State Commission had exceeded its authority and that its order interfered with the commerce clause of the federal constitution. That court held the order void and the case was appealed to the United States Supreme Court.

Inasmuch as the new schedule of rates would apply to an interstate contract and that its effect upon interstate business would not be merely incidental, the Supreme Court held that the Rhode Island Commission cannot increase the contract rate any more than the Massachusetts Commission could reduce it, and that the only chance for relief is in action by Congress.

Four Killed When Steel Derrick Mast Falls

Four men were killed or fatally injured, and seven others hurt Jan. 7 when a lattice-steel derrick mast fell while being erected at Broad St. and Exchange Place, New York City, where the Thompson-Starrett Co. is constructing an office building for the Equitable Trust Co.

The derrick, with a boom about 85 ft. long and a mast about 100 ft., was being raised to its second-stage position. The weight of the mast was approximately six tons. A seat for the mast had been prepared by placing 14x18-in. timbers on the floor girders and lashing them down, then placing and lashing short 14x16-in. timbers as a seat for the derrick footblock. The mast had just been raised by a stiff-leg operating from the street. As riggers were fastening the guys the footblock apparently kicked out, investigation by the Bureau of Buildings of Manhattan revealed, and the two riggers still on the mast were killed in the fall of the mast. The boom still lay on the steel awaiting erection.

Chemical Engineering Building for Iowa State College

Construction will be started in the spring on the first wing of a new chemical engineering building at the Iowa State College, Ames, Iowa. This wing, 75x100 ft., will constitute an industrial research laboratory which at first will be devoted to the development of the manufacture of paper from corn stalks and of other by-products from corn, corn cobs and corn stalks, following the successful research work which has been carried on for some years under the direction of Dr. O. R. Sweeney.

Santa Monica Joins Los Angeles in Sewage Disposal Plan

The cities of Los Angeles and Santa Monica, Calif., have entered into a contract under which construction can begin soon on a joint trunk sewer that will deliver all the sewage from Santa Monica and also from a considerable area within Los Angeles city limits into the north outfall sewer of the Los Angeles system that discharges into the Pacific Ocean at Hyperion. This plan calls for only 9,000 ft. of force main instead of the 5-mile force main contemplated by the joint agreement at first proposed. The plan benefits both cities by using a common trunk sewer for contiguous territory and will do away with the Venice outfall and will retain the Santa Monica outfall for emergency use only.

Under the new plan the joint sewer will begin in Los Angeles territory north of Santa Monica, will run thence through Santa Monica, delivering to a pumping plant in the Venice district annexed by Los Angeles in 1925. The pumping plant will be about 9,000 ft. north of the north outfall, to which it will deliver through a 30-in. pipe under a maximum pressure of about 50 lb. per sq.in. Several kinds of pipe are under consideration for this pressure line. Delivery to the pumping plant will be by a gravity flow line of monolithic construction of diameters ranging up to 42 in. at the plant.

The contract provides for the distribution of the cost of this sewer as follows: Santa Monica is to build the line and pay all costs within its territory. Of the cost of the work outside Santa Monica, both sewer and pumping plant, Santa Monica is to pay 65 per cent and Los Angeles 35 per cent except that because of the deeper trenching made necessary to serve certain Venice territory, Los Angeles is to make a $10,000 allowance on the 65 per cent share.

Rail and Water Terminals to Be Built at Halifax and Vancouver

The chain of new railway terminal warehouses in Canada is to be increased by the erection of new modern terminals in the cities of Vancouver and Halifax. It is understood that separate companies are being formed, that the financing by bond issues of these two projects have been arranged for by Toronto and New York bankers, that properties in both cities have been arranged for, and that plans are now in course of preparation. The Halifax terminal will be known as the Halifax Harbor and Railway Terminal, and the Vancouver terminal as the Vancouver Harbor and Railway Terminal. Control of these companies will be in the hands of the same interests who control the warehouses at Toronto and Montreal. It is also understood that arrangements in the city of Winnipeg are being carried out to include a local modern warehouse in this system. At both Halifax and Vancouver dry and cold storage facilities are being provided, with docks to accommodate both ocean vessels and fishing craft.

Railroads Fail to Agree on New Lines in Oregon

The Southern Pacific and the Oregon Trunk Rys. have been unable to come to an agreement over the construction and joint operation of certain new railway lines in Oregon, according to a statement issued by the Interstate Commerce Commission, and as a result the commission has asked the Public Service Commission of Oregon for its views on the subject.

Early last summer the commission authorized the Southern Pacific, through its subsidiary lines, and the Oregon Trunk Railway Co., a subsidiary of the Great Northern and Northern Pacific to build certain new railway lines in southwestern Oregon and northern California provided they could come to a mutual agreement concerning the joint operation of part of the new lines and portions of existing lines. Details of the proposed construction were given in *Engineering News-Record*, June 24, p. 1014. No construction was to be undertaken until an agreement had been reached between the railroad companies. After several conferences the companies have failed to reach an agreement and the matter is now back in the commission's hands for further action.

San Francisco-Oakland Bridge Project Situation

The discussion of what can and should be done in the matter of building a bridge across the bay between San Francisco and Oakland, Calif., is still actively before the San Francisco Board of Supervisors. After the legality of proposed proceedings was questioned, the city attorney advised the supervisors that within the law (1) the city cannot select a site and prepare plans for a toll bridge to be built by the private company that submits the most favorable proposition; (2) a municipal bridge cannot be privately financed nor can the city issue bonds which are a lien against the bridge only; and (3) the supervisors cannot employ advisory engineers as the board of public works has sole responsibility for engineering information.

Meantime a measure is to be presented to the state legislature, according to press reports, by State Senator Fellom, that would authorize a special state election to vote on a bond issue "of from $20,000,000 to $50,000,000 for the construction of a San Francisco-Oakland toll bridge as a part of the state highway system."

A tabulation of the bridge projects on which franchise has been applied for appeared in *Engineering News-Record*, Oct. 28, 1926, p. 720.

Chicago Plans Building Program Aggregating $200,000,000

Public and private building enterprises at Chicago, involving $750,000 to $10,000,000 each and aggregating more than $200,000,000, are listed in the bulletin of the Chicago Association of Commerce as contemplated for 1927 construction. The building permits issued in 1926 authorized an expenditure of about $366,000,000 for about 14,200 buildings, and as much of this remains to be expended in 1927 it is expected that the volume of Chicago's building work this year will be nearly as great as that of 1926, in spite of some anticipated decline in building activities.

Among the large items are several hotels, office buildings and apartment buildings of 12 to 32 stories. The Board of Education has a program of $20,000,000 for schools, while the plans of different religious organizations for churches and schools aggregate about $10,000,000. The new $10,000,000 post office is contemplated, but construction may not be started this year. Contracts aggregating $7,000,000 were awarded Jan. 4, however, for the new Cook County jail and criminal court building.

SALIENT FEATURES OF PENSTOCKS ON THE CALIFORNIA POWER PROJECTS

Name of Plant	Buck's Creek	Big Creek 2-A	Balch
Power Company	Feather River Power Co.	Southern California Edison Co.	San Joaquin Light & Power Corp.
Static Head	2,548 ft.	2,419 ft.	2,381 ft.
Diameters	54 to 36 in.	96 to 66 in.	60 to 34 in
Kind of pipe	Banded	¼ (length) riveted ¾ (length) banded ½ (length) seamless forged	Banded
Fibre stress allowed in pipe metal (H.P. pipe)	Maximum in shell, 10,000 lb. per sq. in.; in bands 13,300 lb. per sq. in.	10,000 lb. per sq. in. riveted* 10,000 lb. per sq. in. banded 12,000 lb. per sq. in. seamless forged	Average of core and bands 13,500 lb. per sq. in.
Thickness (H.P. pipe)	Calculated to be equivalent of plain pipe, 1.105 to 1.81 in. thick.	¾ to 1¼ in. riveted 1⅝ to 2¼ in. banded 2¾ to 3 in. seamless forged	Bands start where plain welded pipe would exceed thickness of 1/4 in.
Manufacturer (H.P. pipe)	Ferrum Co. of Poland	½ of lower third by Midvale Steel Co. ½ by Bethlehem Steel Co.	Ferrum Co. of Poland
Capacity of hydro unit served	30,000 hp.	132,000 hp. (two units)	40,000 hp.
Scheduled date of completion of plant	About Jan. 1, 1928. (Penstock to be finished in July, 1927)	May, 1928.	January, 1927.

H.P. pipe = high-pressure pipe.
*Upper third, of course, is not H.P. pipe.

Toll Bridge Interests Plan United Front

(*Concluded from* p. 92)

islative matters which may be pending either in Congress or in the different states, we feel that it is to the advantage of everyone of us to get together and form this association as early as possible.

"I might mention that the president of the Investment Bankers Association is, at the present time, considering the formation of a committee to act in conjunction with the Public Service Committee of the Association to look after all matters pertaining to toll bridges as we do in the case of railroads, public utilities, legislation, taxation, business ethics, etc.

"There is one matter of particular importance that requires immediate and concerted action. Congress has, at all times, maintained a very liberal attitude toward toll bridges but it now appears that the Bureau of Public Roads of the Department of Agriculture has become very active against toll bridges and we understand contemplates bringing pressure to bear to have Congress pass such laws as will give the bureau direct control to regulate all toll bridges everywhere regardless of when constructed and whether interstate or intrastate.

"The bureau appears to take the view that federal highways should not and must not be used as feeders, directly or indirectly, to toll bridges, and in certain instances has threatened a state with withdrawal of federal aid from the entire state because of the proposed erection of a toll bridge, not on, but connecting with a federal aid road.

"It is very difficult to tell at this time just what the results of this agitation will be, but unless something is done collectively to combat it, the operation of toll bridges, through regulation of tolls and otherwise, might be made so difficult as to be prohibitive. This may apply to intrastate as well as interstate bridges."

This call has brought a response from the officers of the American Association of State Highway Officials, in the form of a letter from W. C. Markham, executive secretary to state highway departments asking them to work for safeguarding of toll-bridge construction according to the association's resolution reported in *Engineering News-Record* of Dec. 2, p. 911. Referring to the Watson letter Mr. Markham's communication says:

"A careful perusal of this letter will show you the wide spread efforts being made to commercialize the public highways of this country to individual advantage.

"I am reliably informed that an effort will be made to amend the Federal Highway Act so that the building of toll bridges will receive Congressional sanction.

"I think it is quite essential that each State Highway Department confer with the members of Congress from their state and insist that the approval of the construction of toll bridges should be safeguarded according to the resolution passed by the association."

Engineer Loses on Appeal for Fee Sought from County

On the ground that the record did not show any challenge had been made in the lower courts as to whether the act of the state legislature was an infringement of the federal constitution, the United States Supreme Court on Jan. 10 dismissed, without a written opinion, the appeal of K. B. Allen against Joseph A. Lutz, auditor of Montgomery County, O.

Allen was engaged as county sanitary engineer by the county commissioners under authority of a state act and entered into a contract for a sewer district under which he was to receive 3½ per cent of the estimated cost for surveys and the preparation of plans and 3½ per cent of the actual cost for supervising the work. Later, the legislature amended the state act so as to provide that the maximum compensation of an engineer in such work should not exceed the amount received in that year by the county auditor of the county in which the contract was made. Allen's bill for supervision of work exceeded the income of the county auditor of Montgomery County by several hundred dollars and payment of the excess was refused. The state courts held against Allen in a suit for the difference, and by the action of the United States Supreme Court this stands.

Illinois Engineers Plan Varied Program

A varied list of papers on the program for the annual meeting of the Illinois Society of Engineers, at Springfield, Ill., on Jan. 25 to 27, is summarized below. A, Drainage Section: "Unprecedented Rainfall of the Autumn of 1926," C. J. Root; "Runoff During the Floods of 1926," S. A. Greeley; "Dams for the U. S. Bureau Reclamation," J. J. Doland. B, Surveying and City Planning Section: "Proposed Village Zoning Ordinances," J. L. Crane; "Town Planning in Cook County," M. Michelsen; "Subdivisions," H. H. Bremer; "Building Restrictions," Wm. Kramer. C, Electrical, Mechanical and Mining Section: "Future of Electrical Generation and Distribution in the Chicago District," G. M. Armbrust; "Problems in Underground Electrical Conduit Construction," W. G. Kelly; "Precision Measurement of Air Flow by Weighing," J. A. Polson; "Economic Geology of the St. Peter Sandstone," J. E. Lamar; "Use of the Torsion Balance in Locating Oil Pools," Dr. Wm. Bowie.

D, Road and Pavement Section: "Financing Secondary Roads," D. O. Thomas; "Paving Street Railway Tracks," J. I. Catherman; "Tests on Thin Brick Paving," L. W. Teller and J. T. Pauls; "Planning Roads and Pavements for Prolonged Use," H. J. Fixmer; "Joint Construction of Pavements by Highway Departments and Towns," Duncan M. Campbell; "Paving Progress in Illinois," Lee S. Trainor; "Widening Chicago Pavements," J. A. Moore. E, Sewerage Section: "Burning Gas from Imhoff Tanks at Decatur," W. D. Hatfield; "Developments in Sewage Treatment," Dr. A. M. Buswell; "Recovery of Corn Products Waste at Decatur," Dr. Edward Bartow; "The Bloomington and Normal Sewage Treatment Plant," Stanley Pinel; "Sewage Disposal Problem of Denver, Colo.," C. B. Burdick; "Construction Work of the Springfield Sanitary District," W. B. Walraven; "State Supervision of Stream Pollution," M. C. Sjoblom. F, Water Supply Section: "Wells in a Buried River Valley at Sullivan, Ill.," W. D. P. Warren; "Lime Softening Methods at Columbus, Ohio," Charles P. Hoover; "Water Works Improvements at Streator," F. G. Gordon; "Co-ordination of Sewage Disposal and Water Purification," Paul Hansen; "Springfield Water Softening and Treatment Plant," C. S. Timanus; "Operation of the Springfield Water Purification Plant," C. H. Spaulding.

Washington Notes

THE budget presented to Congress recently carried $1,861,060 for the Bureau of Mines and $1,857,580 for the Geological Survey. In the case of the Bureau of Mines the Director of the Budget has requested of Congress $53,340 less than was appropriated for work of the present fiscal year. The Survey's budget is $38,140 in excess of the amount appropriated for the fiscal year to end June 30.

The amount allowed includes only $30,000 for the new economic work of the Bureau. This $30,000 forms a part of the $225,000 which the budget requests for "promoting mineral commerce." Into this paragraph, however, has been grouped the statistical work taken over from the Geological Survey, the coal work taken over from the Bureau of Foreign and Domestic Commerce, the oil shale investigation and several other items.

MINORITY views on the Swing-Johnson Boulder Canyon bill will be submitted to the House of Representantives by Representative Hayden, of Arizona, Representative Leatherwood, of Utah, and Representative Whittington, of Mississippi. Each of the members mentioned will submit a separate minority report.

There is decided opposition to the Swing-Johnson proposal in that the bill as it now reads would make it possible to put the government in the power business to the extent of 1,000,000 hp. The bill does contain a rather obscure alternative for the leasing of units of the dam to those interested in developing power, but in view of official announcements it seems likely that the alternative of selling the power at the bus bar and providing for the joint use of transmission lines is more likely to be undertaken.

Those opposing the bill declare that the joint use of transmission lines is impracticable, but they would have no objection to the measure were that feature eliminated and the government required to lease the dam. If agreement can be reached on those differences it is believed the bill has a chance to pass at this session of Congress.

Much Railroad Construction in Prospect in Canada

Canada is likely to see a pretentious program of railway construction work during 1927. The Canadian National Rys. program is expected to include a line into the Peace River district, which has sprung into so much prominence lately. Other C. N. R. proposals are not yet ready for presentation to Parliament, but as the three-year program of branch-line construction has been practically wound up, it is expected another three year plan will be drawn which may include as many as a dozen branches in the west.

The Canadian Pacific Ry. is confining itself almost exclusive to western work this year. Among the lines it proposes to build, and for which it is asking the sanction of Parliament, are several in Saskatchewan.

The C. B. Hubbard interests are again seeking power to build the Red Lake and North Western Ry. into the new mining area near the Western boundary of Ontario.

Then there is also an application presented by the Manitoba and North Western Ry. Co. of Canada praying for the passage of an act authorizing the construction of a line of railway from a point at or near Theodore, in the province of Saskatchewan.

One work likely to be undertaken in Eastern Canada by the government-owned system will be a 20-mile extension to the Lake St. John line to tap valuable industrial areas.

Complimentary Dinner Given to Frank E. Winsor

The Affiliated Technical Societies of Boston gave a complimentary dinner to Frank E. Winsor, chief engineer, Metropolitan District Water Supply Commission, on Jan. 6. The dinner was in recognition of the coming to Boston of Mr. Winsor in the capacity indicated above after completion of the major part of the additional water supply for Providence, R. I. Some of the speakers at the dinner were F. A. Eustis, chairman of the Affiliated Technical Societies of Boston; Charles R. Gow, consulting engineer of Boston, who served as toastmaster; George T. Seabury, secretary, American Society of Civil Engineers; and Davis B. Keniston, chairman of the Metropolitan District Commission and of the Metropolitan District Water Supply Commission.

Addresses at Short Course for Sewage Plant Operators

Opening addresses in the short course for sewage plant operators at Rutgers University, New Brunswick, N. J., on the afternoon of Jan. 17 will be made by President Thomas, Edward H. Rockwell, dean of engineering, Clyde Potts, consulting engineer and president of the New Jersey Board of Health, and M. N. Baker, associate editor *Engineering News-Record*. Mr. Baker will speak on "The Trend of Sewage Disposal in the United States," and Mr. Potts will speak on "Sewage Disposal and the Public Health."

Construction Equipment and Materials

A Section Devoted to What the Manufacturer is Doing for the Engineer and Contractor

Another Record Year for the Motor Industry

For the twenty-ninth time in its history, the motor vehicle business has established a new record year. According to the National Automobile Chamber of Commerce, the total production of motor vehicles for 1926 was 4,480,000. In 1925, it was 4,336,754. Of these numbers, 530,000 trucks were produced during 1926, while 498,000 were produced during 1925. The number of motor buses in use has increased from 70,000 to 80,000 during the 12 months of 1926. There have been 15,000 motor buses produced during the past year. There has also been an increase in motor truck registration, the 1925 figure being 2,441,709, while the figure quoted for 1926 is 2,810,000. An increase of 3 per cent over exports is also recorded. The export business represents 12 per cent of the business of the automobile factories. There is in the United States something over 80 per cent of the world's registration of motor vehicles.

Manufacturer's Engineers Inspect Equipment in Field

An annual inspection tour of the engineers in charge of the road maintenance and construction equipment in the organization of Littleford Bros., Cincinnati, Ohio, is made each year. The trip for this year has recently been completed. In a period of four weeks the engineers examined much of the company's asphalt road, maintenance and construction equipment that is in service in the states of Ohio, West Virginia, Pennsylvania, Maryland, Delaware, New Jersey, New York and Connecticut.

The object of this tour is not only to watch the machines in operation but to interview the men in charge of them, offer suggestions for obtaining a greater degree of efficiency and learn of any changes that might be made in the machines. Such a service is proving very helpful to the company in keeping abreast of the wants and necessities of the users of its equipment.

Business Notes

COMMERCIAL SHEARING & STAMPING CO., Youngstown, Ohio, has added a new line of contractors' equipment to its standardized line of pressed steel products. The new products include mortar mixing boxes, mortar boards, mortar hod supports, tool boxes, collapsible saw horses, etc. All are made from blue annealed steel.

CELITE PRODUCTS CO., Los Angeles, announces the appointment of Dr. M. L. Hartmann as technical director of the company with research laboratories located at Lompoc, Calif. Dr. Hartmann assumes his new position after resigning as director of research of the Carborundum Co., Niagara Falls, N. Y. He was formerly head of the department of chemistry, South Dakota State School of Mines, and has been with the Carborundum Co. for the past nine years.

AMERICAN BROWN BOVERI ELECTRIC CORP., New York City, announces that the gross business of the corporation and its subsidiaries for 1926 is estimated by President Laurence R. Wilder at approximately $25,000,000. For 1927 he predicts a gross of some $35,000,000. Two new directors have been elected to the company—Elisha Walker, president and chairman of the board of Blair & Co., Inc., investment bankers, and Henry Lockhart, Jr., vice-president of Blair & Co., Inc.

FOOTE CO., INC., Nunda, N. Y., announces that Frank Hall, 152 West 42nd St., New York City, has been appointed general distributor for Connecticut, that part of New York below a line drawn from the upper border of Connecticut to the upper border of Pennsylvania and the upper half of New Jersey.

BUFFALO FORGE CO., Buffalo, N. Y., and the Buffalo Steam Pump Co. announce that their Philadelphia office will be in charge of W. S. Koithan and R. W. Pryor, Jr., who have for many years been joint managers of the New York office. They will also manage the New York district from the Philadelphia office.

Manufacturers and Trade Associations

Calendar

Annual Meetings

NATIONAL SLATE ASSOCIATION, New York; Annual meeting, New York, Jan. 18 and 19, 1927.

NATIONAL SAND AND GRAVEL ASSOCIATION, Washington, D. C.; Annual meeting, Cincinnati, Jan. 17, 18 and 19, 1927.

NATIONAL CRUSHED STONE ASSOCIATION, Washington, D. C.; Annual meeting, Detroit, Jan. 17-20.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION, New York; Annual Meeting, New York, Jan. 24, 1927.

AMERICAN WOOD PRESERVERS' ASSOCIATION, Chicago; Annual meeting, Nashville, Tenn., Jan. 25-27, 1927.

NATIONAL ASSOCIATION OF RAILROAD TIE PRODUCERS, St. Louis; Annual meeting, Nashville, Tenn., Jan. 27 and 28, 1927.

HOLLOW BUILDING TILE ASSOCIATION, Chicago; Annual meeting, Chicago, Feb. 10 and 11.

COMMON BRICK MANUFACTURERS ASSOCIATION, Cleveland; Annual meeting, Chicago, Feb. 21-26, 1927.

NATIONAL BATTERY MANUFACTURERS' ASSOCIATION, New York; Annual meeting, Philadelphia, March 11 and 12, 1927.

HYDRAULIC SOCIETY, New York; Annual meeting Chicago, March 25, 1927.

WATERWORKS MANUFACTURERS ASSOCIATION, New York; Annual meeting, Chicago, June 6-10.

New Publications

Air Compressors. — WESTINGHOUSE TRACTION BRAKE CO., Pittsburgh, Pa., in its catalog T-2032 issued September, 1926, describes its type 3 VS and 3 VD motor-driven air compressors. They range in capacities from 200 to 700 cu.ft. per min. The 3 VS is a single acting, the 3 VD a double acting compressor, while both are 3 cylinder, single phase machines. Illustrations of installations and also of machine details are given in addition to specification tables showing the different sizes to be used and the different types available for practically any phase, cycle or voltage.

Trench Braces.—TEMPLETON, KENLY & CO., LTD., Chicago, has recently issued a folder giving specifications and descriptions of its trench braces. A page is also devoted to its lift jacks of various types. The trench braces are a new product with the company.

Snow Removal—AMERICAN AUTOMOBILE ASSOCIATION, Washington, D. C., has published a booklet entitled "Snow Removal from Streets and Highways." The information contained in it has been compiled from data received in reply to a questionnaire. The information is presented in the form of articles dealing with a specific phase of the snow removal situation.

Wrought Iron Pipe.—READING IRON CO., Reading, Pa., devotes its bulletin No. 2, a 15-page booklet, to illustrations and descriptions of the use of its wrought iron pipe under various conditions, citing a number of installations that are many years old. In the back of the bulletin information is given on the manufacture of wrought iron pipe and methods for testing it.

New Developments

Ice-Breaking Machines for Clearing Roads and Streets

A machine growing out of the development of equipment in use for many years in the natural ice industry for leveling the ice at the time of harvesting was recently placed on the market by Chas. Hvass & Co., Inc., New York City, for removing ice from roads and streets. As shown in the illus-

Obituary

CAPT. HAROLD C. LYONS, Corps of Engineers, who served with the 20th Engineers, both in training and overseas, died in Washington, D. C., Dec. 30 after a long illnes, at the age of 43 years. His most recent station was at Carnegie Institute of Technology at Pittsburgh, where he was on duty with the Reserve Officers Training Corps. Captain Lyons was a graduate of Princeton University and before his war service, which began in 1917, was engaged in engineering and some contracting work in New York.

GORDON P. HAYMAN, engineer of the public works department of British Columbia, slipped from a precipice along which construction was being done on the Cariboo Road east of Lytton, B. C., and was killed.

WILLIAM M. N. HAYS, Oil City, Pa., a civil engineer who had surveyed some of the first and many later pipe lines in Pennsylvania, died Dec. 29 at his home in Oil City, aged 87 years.

JOHN CURTIS PATTERSON, consulting engineer, Philadelphia, Pa., died Jan. 6 in that city, aged 69 years. He entered technical training at the University of Pennsylvania in 1874 but in his senior year left to join an engineering expedition which did railway construction work in South America. After four years in South America and Mexico he became assistant engineer of the Reading Ry. and was later chief engineer of the Northeast & Western R.R. and the Pittsburgh & Eastern R.R.

JOHN A. SPILMAN, an engineer and president of the Maryland Dry Dock Co., Baltimore, died Jan. 9 of pneumonia at a Baltimore hospital. Mr. Spilman graduated from the United States Naval Academy in 1900 and took a special course in naval construction at the Massachusetts Institute of Technology. Later he had charge of work at the Norfolk and Brooklyn navy yards, at the latter especially during the War. He resigned from the navy in 1920 and a year later went to Baltimore with the Maryland Dry Dock Co.

GEORGE SIMPSON, formerly chief engineer, Poole Engineering & Machine Co., Baltimore, Md., died December 18, age 79 years. He was chief engineer until 1896 when he resigned to become supervising engineer for the Farrel Foundry & Machine Co., Ansonia, Conn. After five years service in this capacity he returned to the Poole company as consulting engineer, but retired about two years ago on account of declining health.

CALVIN C. HOUGH, engineer of design for the Brooklyn-Manhattan Transit Co., died Jan. 4 of pneumonia at his home in Brooklyn, at the age of 42 years. Mr. Hough was educated at Drexel Institute in Philadelphia and in 1905 entered the steel car shops of the American Car & Foundry Co. at Berwick, Pa. From 1906 to 1914 he was employed as inspector, draftsman, designer and engineer for the Brooklyn Rapid Transit Co., the Pennsylvania Tunnel and Terminal Co. and other firms on the design and construction of bridges, buildings, and tunnels; then, to 1919, he was assistant engineer in charge of design of elevated railroad extensions for the New York Municipal Railway Corporation. From 1919 to 1923 he was structural engineer of the Brooklyn Rapid Transit Co. In 1925 he became engineer of design for the B.-M.-T. company. He was vice-president of the Brooklyn Engineers Club for two years.

Engineering Societies

Calendar

Annual Meetings

SOCIETY OF AMERICAN MILITARY ENGINEERS, Washington, D. C.; Annual Meeting, Washington, D. C., Jan. 17, 1927.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City; Annual Meeting, New York City, Jan. 19-21, 1927.

ASSOCIATED GENERAL CONTRACTORS, Washington, D. C.; Annual Convention, Asheville, N. C., Jan. 24-28, 1927.

ENGINEERING INSTITUTE OF CANADA, Montreal; Annual Meeting, Quebec, Feb. 15-17, 1927.

AMERICAN CONCRETE INSTITUTE, Detroit, Mich.; Annual meeting, Chicago, Ill., Feb. 22-24, 1927.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, Chicago, Ill.; Annual Convention, Chicago, Ill., March 8-10, 1927.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston, Mass.; Annual Meeting, Chicago, Ill., May 9-12, 1927.

The Illinois Section of the American Water Works Association will hold its annual meeting Jan. 27 and 28 at Springfield. M. L. Enger, professor of mechanics and hydraulics, University of Illinois, is secretary.

The Montclair (N. J.) Society of Engineers, at a meeting on Jan. 10, voted to establish a prize of $100 to be given annually to that member of the high school graduating class who shows himself best fitted to become an engineer and who proposes to do so. In view of a rumor that a druggist is to be appointed as a member of the State Highway Commission in place of Walter Kidde, a New York engineer resident in Montclair, the society adopted a resolution expressing the belief that the position could best be filled by an engineer rather than a druggist. Addresses on zoning, from town and state viewpoints, were made by Flavell Shurtleff, secretary Committee on Regional Plan for New York and Environs, and George S. Burgess, vice-president New Jersey Chamber of Commerce. The chairman of the evening was H. A. Lardner, mayor of Montclair and vice-president of the J. G. White Engineering Corporation.

Personal Notes

W. A. HARDENBURGH, since 1921 director of the Bureau of Sanitary Engineering of the Jefferson County (Ala.) Board of Health, and director of rural sanitation for the city of Birmingham, Ala., has resumed the position of associate editor of *Public Works* which he filled from 1914 to 1917 and which he left for war service. During the War he was assigned to the U. S. Public Health Service and was engaged in cantonment sanitation and sewerage research.

JAMES M. FOURMY, who was state highway engineer of Louisiana in 1925 but later went into consulting practice in Hammond, La., has been appointed state highway engineer for a second service in that capacity.

E. E. TERRELL has been appointed county highway engineer of Hennepin County, Minnesota, the county in which Minneapolis is situated, and will have charge of extensive highway work which the county has planned.

D. C. WARFEL, for the past six years county engineer of Okanogan County, Washington, has resigned to go to California where he will locate either in Los Angeles or Oakland. In Washington, before his work in Okanogan County, he was county engineer of Perry County.

GEORGE C. MASON, Portland, Ore., announces that, following the closing of the Portland office of the Hurley-Mason Co. on Dec. 31, he has opened an office as consulting engineer in the Gasco Building in Portland, for practice in building construction, including design, construction and financing.

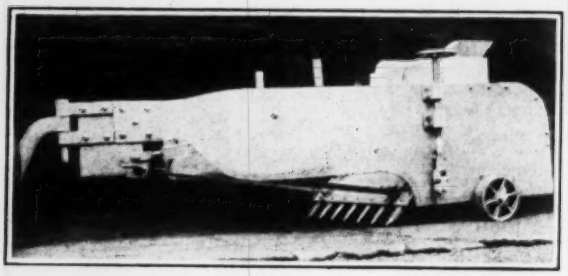
R. D. STEWART, chief engineer of the Denver & Salt Lake R.R., with headquarters at Denver, has retired, due to ill-health. A. A. Matthews has been appointed to the office.

JAY T. WILLIAMS, civil engineer and chief building inspector for the city of Denver, Colo., was elected president of the Civitan club of that city to serve during 1927.

THOMAS L. WATKINS, of Albany, N. Y., has been appointed by Col. Frederick Stuart Greene, state superintendent of public works, to serve as state engineer of New York. In this position he is the first appointed state engineer and succeeds Roy G. Finch, the last elected state engineer. Mr. Watkins has been assistant to Frank R. Lanagan, former deputy state engineer. The appointment is in line with the provisions of the reorganization act which became effective Jan. 1.

FREDERICK PALMER, president of the Institution of Civil Engineers, London, arrived in Canada during the latter part of December to begin the study of the Hudson Bay Railway situation which he has been commissioned to make for the Canadian government.

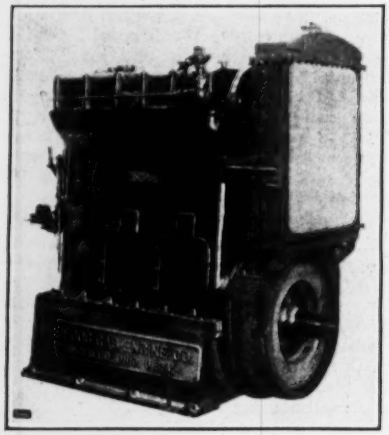
tration, it consists of ½-in. side plates braced front and rear forming a chassis mounted on V-shaped wheels (flat wheels are shown in the illustration) and carrying an adjustable cutter bar. Either end of this bar may be raised or lowered to an angle fitting



the contour of the street or road. The teeth, of which there are 8 set 6 in. apart, are claimed to be set so as to protect the pavement from damage. The breaker will remove ice from 1 to 8 in. thick. It can be drawn by motor truck or tractor, a drawbar for this purpose being furnished. A width of 48 in. can be cleared at one time while the wheels are spaced 60 in. apart so as to fit in the ruts in the street formed by motor vehicles. The weight of the machine is 3,000 lb.

Light Weight Diesel Design for Road Equipment Use

A light weight, medium high speed Diesel engine has been designed by the Foos Gas Engine Co., Springfield, Ohio, for application to such equipment as power shovels, locomotive cranes, in-



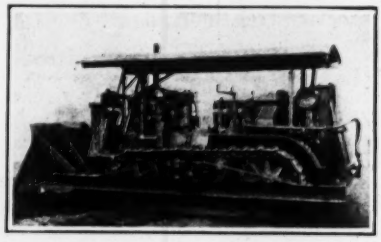
dustrial locomotives, ditchers, etc. Features of the engine are complete inclosure, automatic lubrication, speed range up to 900 r.p.m., provision for attaching radiator, fan, clutch, etc.

New Air Equipment

A 220-cu.ft. portable compressor of a 5¼x5-in. size and a new clay digger are the most recent announcements of the Chicago Pneumatic Tool Co., New York City. The compressor is equipped with a Hercules motor and a special unloading arrangement that controls the gas and water when the machine is unloaded, thus making the entire operation of the machine automatic. A special sectional radiator is also used. The deck frame is made from a steel casting to withstand the rough usage to which many portable compressors are subjected. The compressors can be furnished trailer mounted on steel wheels or on rubber tired wheels as illustrated. It is claimed that the size of the new clay digger has been arrived at after some four or five years of careful recording of details in connection with various classes of material to be handled by compressed-air operated clay diggers. This new piece of equipment is said to be considered a universal tool for all average conditions.

Hydraulic Bulldozer for Caterpillar Attachment

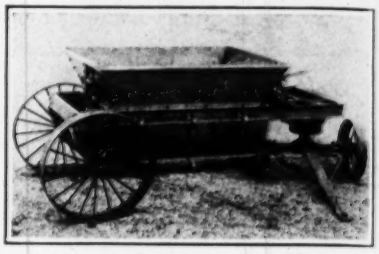
A recent product of the LaPlant-Choate Mfg. Co., Cedar Rapids, Iowa, is a hydraulic operated bulldozer designed for attachment to both the "30" and "60" models of the Caterpillar



tractor. The bulldozer is operated by the tractor driver. As shown in the illustration, it is mounted on a sub-axle so that the weight is carried on the tractor, thus giving it increased traction for hard pushing.

Steel Bottom-Dump Trailer Uses New Refinements

The all-steel four-wheel bottom-dump trailer recently developed by the Miami Trailer-Scraper Co., Troy, Ohio, has been designed as a low-cost, slow-speed trailer for tractor operation, and has a carrying capacity of 2½ tons and is built for an extremely short turning radius. The wheels are mounted on Timken tapered roller bearings, two bearings to each wheel. Alemite lubrication is also used on the wheels. The axles are of 4-in. I-beams, while the chassis is of 6-in. 10½-lb. rolled steel channels. Wide carriage steel wheels 7 in. on the rear and 5 in. on the front are used. The tread is 56 in. center to center on the rear and 40 in. center to center on the front, while the wheel-base of the trailer is 8 ft. 4 in. The body is of 10-gage steel plate, bottom dump doors being operated by winding and dumping levers. The water level



capacity of the body is 1⅓ yd., while a top box provides for a rounded load of 2½ yd. The weight is 2,260 lb.

Electric Tie Tamper with Only One Moving Part

By using a series of magnets energized by alternating current, the Syntron Co., Pittsburgh, Pa., has developed an electric tie tamper which contains no motors, gears, or eccentrics. It contains only one moving part, the piston, which is supported in two bushings and strikes 1,200 blows per minute. The action of the tamper is controlled by a trigger switch in the lower handle. The power plant weighs only about 750 lb. and is easily portable. It may also be used to operate any other portable electric tool. The power unit runs about 8 hr. on 5 gal. of gasoline. For the four-tamper outfit this power plant consists of a four-cylinder Le Roi, 15-hp. water-cooled engine direct connected to a 6-kva., 110-volt, a.c. generator. The weight of the tamper is 56 lb. It is claimed that men using the machines tamp more easily, with less fatigue and that the tamped ballast will stand up longer under heavy traffic.

Tests recently conducted on the Monongahela R.R. on track ballasted with slag showed costs ranging from 2½ to 4.6c. per tie with these tampers as compared with 9 to 10c. per tie for hand labor. Six men with these tampers replaced a gang of 15 men tamping by hand. Tampers have also been

in use on the Pennsylvania, the Northern Pacific, and the Pittsburgh & West Virginia railroads.